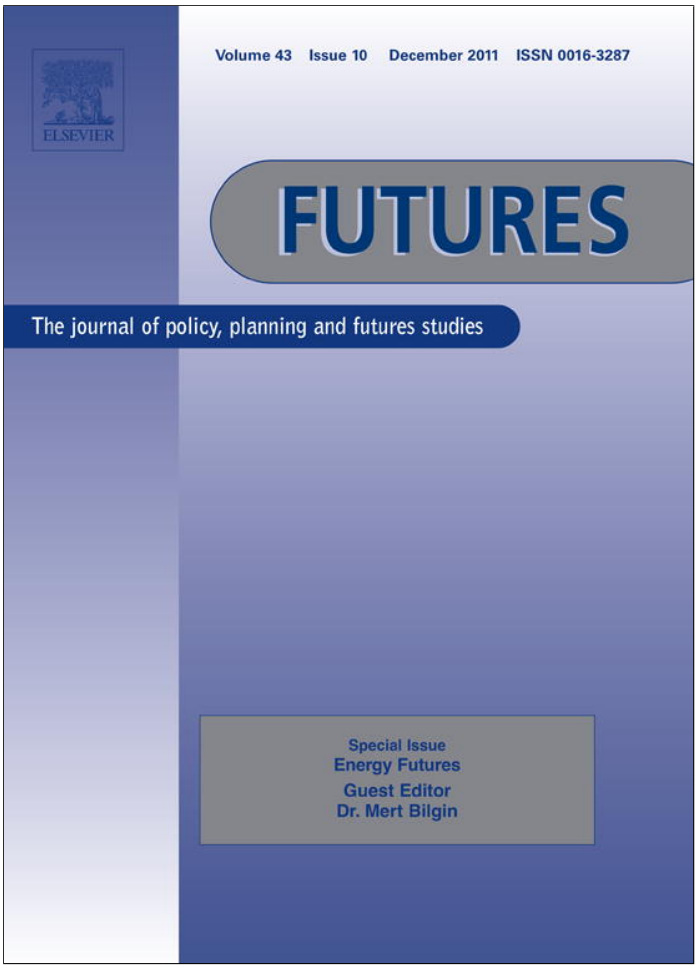

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Oil at 150$—The tipping point for changing course of civilizations?

Igor Matutinović

GfK, Center for Market Research, Draskoviceva 54, 10000 Zagreb, Croatia

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ABSTRACT

The present work offers a systemic perspective on post conventional oil futures. It is based on the model that accounts for a causal relationship between a dominant worldview in a society and the societal choice of technology and institutions, which then constrain and direct dynamics at the level of production and consumption. The *Business as usual* scenario provides an idea as where the world might be heading under the assumption of a myopic and unchanging worldview. The *Western group leads the process of change* scenario describes an evolutionary cascade of change in the Western group, which starts with a substantial change in a dominant worldview. Note that this substantial change is not a revolution – although its institutional solutions appear very challenging today, they do not necessarily stand out of the capitalist democracy. Finally, the third scenario is about *global governance* – a future that would leave least unknowns and least threats to Western civilization.

1. At the crossroads

Within a few decades, if not earlier, the Western civilization and the world as a whole will face the major energy challenge since the beginning of the industrial revolution: conventional oil, our cheapest energy source with highest EROI,[1] will peak and then decline in the years thereafter. The ongoing debate about the timing of peak oil or the shape of the oil depletion curve[2] [1,12,39,66,67] does not change the fact that oil, natural gas, and coal are finite resources and that industrial civilization sooner or later will have to adapt to other energy sources or risk collapse. The possible simultaneous onset of climate change and peaking of oil supply represent unprecedented challenges driving this energy transition [27]. While hopes for energy transition are usually placed upon renewable sources and nuclear power plants, the magnitude of change of our current energy habits is great: in 2006 fossil fuels accounted for 80.9% of total primary energy supply with oil share of 35% [30]. It will be hard to break our dependence from fossil fuels according to the recent Reference Scenario of the International Energy Agency which forecasts that fossil fuels will account for 77% of the increase in world primary energy demand in the period 2007–2030, with oil demand rising to 105 mb/d in 2030 [7]. The 2008 edition of World Energy Outlook summarizes the current situation and the challenges that lie ahead in clear and unambiguous terms:

> "The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable – environmentally, economically, socially. But that can – and must – be altered; *there's still time to change the road we're on*. It is not an exaggeration to claim that the future of human prosperity depends on

E-mail address: igor.matutinovic@gfk.com.

[1] Energy return on energy investment.

[2] The timing of the peak of extraction of conventional oil is uncertain due to unreliable data concerning known recoverable reserves and because technology improvements may increase the amount of oil recoverable. The major unresolved issue about the shape of the world oil extraction curve is whether it is bell-shaped (the so called Hubbert's curve), which implies a peak followed by a steep decline [14], or it has some other form like, for example, an undulating plateau followed by a gentle declining slope [12].

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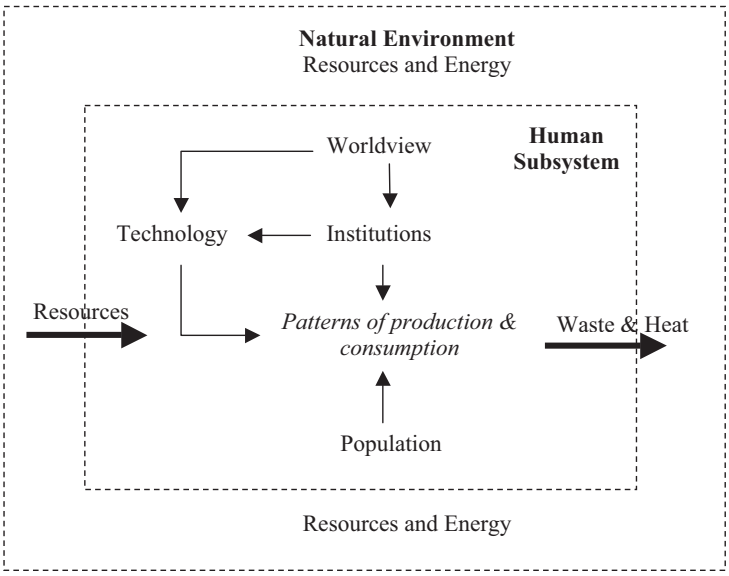


Fig. 1. Hierarchical model of causal relationship.

how successfully we tackle the two central energy challenges facing us – transformation to a low-carbon, efficient and environmentally benign system of energy supply. What is needed is nothing short of an energy revolution" [51].

Whether we will have an energy revolution or, instead, an "energy evolution", markets and the price of energy may play an important part in the process. This does not mean, as we will see later, that markets and prices would solve the energy challenges by themselves, nor will our life-styles necessarily remain the same after the transition to post-oil era.[3] Most probably we will have to review our notion of "prosperity" and decouple it from material growth. However, unless we wish abandoning our civilization to the whims of revolutionary storms, of which bitter effects we still keep fresh memories, it is advisable to examine how far we can stretch the present socioeconomic system to meet the challenges. Before we embark on that theme, it is necessary to provide a system-theoretic framework that will guide the analysis and search for solutions [5]. This is the task of the next section.

2. Theoretical framework

In order to understand more clearly the scope and the limits of markets and public policy, or the interaction between self-organization and design, and to place our discussion into appropriate theoretic framework, let us examine briefly a model that I dealt with in detail elsewhere [40–42].

According to Salthe [58] we can represent phenomena in complex systems by using three elementary hierarchical levels in a model: lower level initiating conditions and upper level boundary conditions acting as constraints on a *focal level process*. The system components that act as *lower-level constraints* are generative and propose possible results, while components that appear as *higher-level constraints* are regulatory and dispose – they "dominate" the activities and productivity of focal level processes [58]. This is possible, among other things, because the rate of change of processes at higher levels is significantly slower than the ones at lower levels and, therefore, appears to the latter as a relatively constant environment. Fig. 1 shows hierarchical, top-down, direction of causality (and constraints) that connects culture, institutions and economic activities in a coherent and systemic way. It starts at the prevailing worldview of a society, which defines its widely shared values and beliefs.[4] Within the boundaries of a certain worldview, a society creates and changes its institutional framework, which eventually constraints the activities of economic agents.

The model postulates interaction (feedback) between contiguous levels and occasional transitivity across distant levels in the hierarchy. When a bottom-up interaction occurs (as it does in the case of a feedback) it is referred to as a perturbation occurring at the upper level. In the case of transitivity, its effects are diminishing with the distance between the levels and therefore, the hierarchical structure of causality is always preserved [58].

[3] Under post-oil era I do not assume the absolute disappearance of oil from economic usage. I refer to it as to a relatively long period during which the supply of conventional oil, and soon afterwards also of non-conventional oil, will first stagnate for a short period (the peak) and then start decreasing at a certain yearly rate, depending on the slope of the depletion curve.

[4] I define worldview as a set of beliefs, symbols, values and segments of objective knowledge that are widely shared in a given society over a considerable period of time (for at least the life-span of one generation). This definition explicitly introduces objective knowledge [54] as a constitutive part of a worldview.

In terms of the *specification hierarchy* [59], which looks at the embeddedness of phenomena at the integrative levels of their classes, the hierarchical relation {worldview dynamics {institutional dynamics {economic dynamics}}} means that no radical change in economic sphere is possible unless the institutional framework is changed, which will only happen if the ideational superstructure changes in the first place. Institutions refer to markets, and other rules, norms and routines that organize and constrain economic behavior at the focal level below. From the history of technological change [11] and from early economic history [52] we learn that technologies, like institutions, do not arise in a cultural vacuum. Berkes and Folke [2] grasped this contingence in a simple statement, saying that the technologies we develop reflect our cultural values. Therefore, in the model technology is sub-ordained to the dominant worldview of the Western civilization. Institutions influence technology through direct interaction at the same hierarchical level by providing more or less enticing environment for investments, and by setting rules of ownership and technical operation (e.g. patents and safety). Technologies provide yet another constraint on economic dynamics at the focal level.

Here we observe patterns of production and consumption that comprise all interactions and exchanges between industry and households in an industrialized capitalist economy. At this level, we seek to induce changes and engender a process of adaptive behavior with respect to challenges identified in the first section. Below, we find human population with its biological needs and cognitive capacities, which aggregate in system components – firms and households – at the focal level. By putting population in disaggregate form at the level of initiating conditions, I wish to emphasize that humans can organize their way of making a living at the focal level (patterns of production and consumption) in many different ways, and that any particular outcome has been "screened out" by institutional and technological constraints at the next level above. The focal level and the level below jointly form a *scale hierarchy* [58] of parts nested within wholes [national economy [firm/household [individual]]].[5]

Finally, the economy is embedded in the natural environment – a meta-system which constrains the human subsystem by providing a set of initiating and boundary conditions. As a material cause, natural environment, in its biotic and abiotic aspects, provides *initiating conditions* for socioeconomic activities. On the other hand, natural resources like arable land, fresh water, fish stocks, and oil reserves are either finite or non-renewable so their availability represent a *boundary condition* for socioeconomic change and material growth. Another aspect of natural boundary conditions is represented in environment's finite "sink" capacity – in its limited absorption potential with respect to waste, pollutants and greenhouse emissions produced by anthropogenic activities. We can summarize the entailments among variables in the model in terms of Aristotelian causality, where natural environment stands for material cause, technology for efficient cause, institutions for formal cause, and worldview for final cause of a particular pattern of production and consumption.

I am advancing here the hypothesis that it is technically possible to impose new constraints on the behavior of agents – firms and households – in order to meet the challenges of energy transition. In the next section, I will discuss each of the levels in more detail, and within the context of the issues related to oil as one of key energy sources of industrial civilization.

3. Analysis of constraints

3.1. Resources and energy

If fossil fuels are the key energy source of industrial civilization, then oil, with its numerous refined products, is its most versatile component which stands as *initiating condition* for numerous socioeconomic activities – from transportation to petrochemical industry and food production. The sector perspective provides a succinct outlook of the variety and relative magnitude of global use of oil at the next hierarchical (focal) level of our model: transportation 64%; industrial fuel 8%; heating 7%; lubes, waxes, and other 7%; plastics and petrochemicals 6%; road construction 4%; refinery fuel 4% [16]. The world economy counts on stretching this initiating condition further in the future – from around 85 million barrels per day in 2008 to 105 mb/d in 2030; an increase of around 24% [31].

From the perspective of *boundary conditions*; oil is a finite resource and its recoverable reserves are putting a definite constraint on economic growth, global distribution of life-styles and the level of integration of global economy. New oil field discoveries have been declining since the mid sixties of the 20th century [16]. Therefore it is unlikely that we will find new large reserves in the future. IEA estimates ultimately recoverable conventional oil resources, which include initial proven and probable reserves from discovered fields, reserves growth and oil that have yet to be found, at 3.5 trillion barrels [30]. Most of earlier made estimates cluster around a value of two trillion barrels of which some 900 billion have been already consumed [23,48]. However, a recent study [1] disputes the IEA 2008 projections of the world oil production by 2030, and claims (basing their estimate on the same quantities used by IEA) that it will be below today's – around 75 MB/d. The authors conclude that "the world appears most likely to have passed the peak of global oil production and to have entered the descent phase. If this is the case, then the world has reached the Peak of the Oil Age." Recent report from UK Energy Research Centre [61] found that total production from existing fields is declining 4% a year, meaning that the world has to add 3 million barrels of daily production capacity annually just to stand still, equivalent to developing a new Saudi Arabia every three years. They put the peak of conventional oil production before 2030.

[5] I do not show all these levels in the model because of visual simplicity and clarity.

In any case,[6] it appears that we are close to the point where our growing demand for oil will meet permanently shrinking supply – a change that will trigger a process of world-wide adaptations to new boundary conditions. As Hirsch [25,26] pointed out, governments should initiate mitigation crash program about 20 years before forecasted peaking of oil production. That means roughly now.

3.2. Population

The relationship between energy and population is both simple and complex: it is simple because it is straightforward to relate population growth with growth in energy consumption; it is complex because per capita energy consumption, beyond energy intake strictly necessary for survival, appears to be very wide and apparently unbounded. The world will probably add 2.2 billion people by 2075 and peak at 9 billion[7] [37]. Most of the people will be living in countries that have been industrializing in the past two decades and will thus tend to increase, year after year, the growth rate in their per capita oil consumption. On the other hand, a stable or mildly declining population of industrialized rich countries[8] will tend to preserve their life-styles and relatively high per capita consumption of energy in general, and oil in particular. This situation, ceteris paribus, is likely to produce intense resource competition and increase the chances of international conflicts for oil.

3.3. Worldview

Each individual holds a certain set of values and beliefs that relates her or him to the world at large. Certain values and beliefs are widespread within a population: for example, most people in Western societies place high value in human rights and individual freedom and believe in the power of science to solve, in one way or another, any challenge that humanity may face in the foreseeable future.[9] In a similar fashion, nearly all politicians, and the vast majority of economists and lay people believe that our economies are set to grow indefinitely and that our ways of life will continue as they presently are. A recent public opinion survey in 31 European countries showed that only 3% of respondents place energy among two most important issues in their country [21]. Based on this finding, we can conjecture that, by not being seriously concerned about energy in relative terms, most of the European population implicitly believes that energy and oil are going to be abundant in the foreseeable future [55]. This is supported by another public opinion survey[10] conducted in the Unites States in 2007: on the question "why do you think the price of gasoline is so high right now?" only 3% of respondents identified "shortage of oil", while most respondents blamed the oil companies and the US administration.[11] Consequently, we behave as if oil reserves depletion or adverse effects of climate change will happen, if ever, in some undefined future time, and, perhaps, by that time the science will find new solutions to both issues. Until most of the voters and political decision makers share such values and beliefs they will not take action in the institutional and behavioral spheres to change any of the current habits. The "business as usual" inertia is contingent to our prevailing worldview.

3.4. Technology

Our worldview may affect which technologies our societies would tend to adopt, and which they would reject or put on hold. For example, our notion of "natural" is value-laden, and, therefore, influences our attitude towards genetically modified organisms, which is often perceived as a human messing-up with "natural order". Such an attitude may affect the scope and the pace of introduction of products of biotechnology in our daily life. Similarly, the high value that our culture puts on "freedom" and "individuality" supports individual transport in cities and all the related technologies that make it function. In a general sense, unless the population at large changes its view of the world, consumers will not seek and businesses will not invest in technologies that may meet the combined challenges of peak oil and climate change. Alternative technologies, like electric cars, will continue to be confined to a niche and technological-organizational solutions for mass urban transport that would meet the requirements of large masses of commuters may not develop.

3.5. Institutions

In the similar way, unless we change our beliefs and values about the world at large, our political systems will be unable to introduce required institutional changes that would guide investment and consumption choices towards socially desirable

[6] If we exclude CERA's optimistic estimates of an undulating plateau between 2030 and 2055 year after which oil production starts declining [32]. Potential increase of oil extraction from individual exporters like Iraq, further liberating of drilling in deep waters, and relying on a strategically diversified supply of natural gas [3,6,67], can only shift the problem a few years in the future.

[7] This is the median value of projections with 80% prediction interval 6636–11,652 million [37].

[8] Recent study shows that at high levels of development fertility increases with Human Development Index in many but not in all countries [64]. Therefore, we cannot take for granted that population in more developed countries will continue to decrease.

[9] See, for example, the public opinion study conducted in EU which dealt with values and attitudes of European citizens [20].

[10] Gallup Poll. May 21–24, 2007. $N = 1007$ adults nationwide, drawn from Gallup's household panel, which was originally recruited through random selection methods. MoE $\pm$ 4 (for all adults) [53].

[11] On the other hand, judging by issues that dominate the Energy blog at the Financial Times web site, we can infer that business community shows much more concern about our energy future and explicitly less belief in the abundance of oil [28].

goals: adapting to growing scarcity of fossil fuels and reducing greenhouse emissions. Political system cannot impose different behavioral patterns via new rules, habits and norms if politicians and voters at large do not believe that these are both indispensable and valuable for a society.

Western economies are based on markets, and a great deal of public and political expectations to find potential solutions to both energy and climate change challenges is being placed on that institution. There is a generally shared *belief* in a society that markets are up to that expectation. Markets are social technologies – a set of processes or routines used to get things done where the doing involves coordinating the actions of independent individuals or organizations [47]. To understand how industrialized societies can use markets and state policies to achieve aforementioned socially desirable goals we have to address briefly the systemic nature of modern market economy.

Modern economies are composed of a myriad of diverse firms which form a particular network of functional interdependencies and business flows (both material and non-material). Business interactions among firms are governed by an autocatalytic process which directs resources towards more efficient units via its competitive and selective properties, stimulating *growth* and overall *performance* of all agents [43,44]. If we look back at the past 200 years of Western capitalism, we note that sustained economic growth and technological progress (performance) have been its defining historical properties. The process of competition is not only raising the performance with respect to existing products and industrial processes but it is responsible for continuous creation of novelty (innovations) at the level of economic system.[12] This is one of *the key social benefits that market economy provides to the society*: by creating favorable conditions for innovations it raises the chances that a society will be able to respond to unknown future challenges coming from the ever-changing environment. Another important feature of markets, relevant for our discussion, is their capacity to process information and divide tasks related to production of goods and services in a decentralized manner. This is usually referred to as a self-organization property which has successfully survived historic tests against alternative models of social organization of production.

Having said that, I need to emphasize that self-organization is not to be equated with *laissez-fair* and neo-liberal ideology. The fact that markets perform effectively[13] in many but *not in all* areas of social interest is not because they are "free" of any government interference but because they were institutionally *designed* and redesigned over the past two centuries to be socially effective [44,45]. The key point for the present discussion is that markets are able to self-organize their production and distribution activities under *varying constraints* imposed by a society via the state administration. That means that the state can introduce a new set of constraints in a market economy with the aim to reach certain, socially desirable goal, like transition from individual transport to public transport, and then let self-organizing agents to find their best way how to do it, or to *work out the details*. The role of the state, however, does not stop there: as we have seen it confirmed in the last world recession, markets (and the capitalist system) can seriously stumble against its own workings and, therefore need to be occasionally bailed out by the state.[14] This fact points out at the organic relationship between the markets and the state in complex industrialized societies: self organization and design are not confronted, but they inexorably support each other [44,45].

3.6. Patterns of production and consumption

At the focal level we observe the process of all-encompassing economic interactions and exchanges which depend on the possibilities generated at lower levels. We shall limit our discussion on energy and more specifically on oil industry. Current patterns of production and consumption characteristic of industrialized market economies generate global trends in energy supply and consumption that are, according to World Energy Outlook, "patently unsustainable – environmentally, economically, socially" [51]. The sustainability issue has been repeatedly addressed by many social and natural scientists in the past fifty years. It reminds us that solutions to oil scarcity are systemically related to other issues like, for example, climate change and degradation of ecosystems.

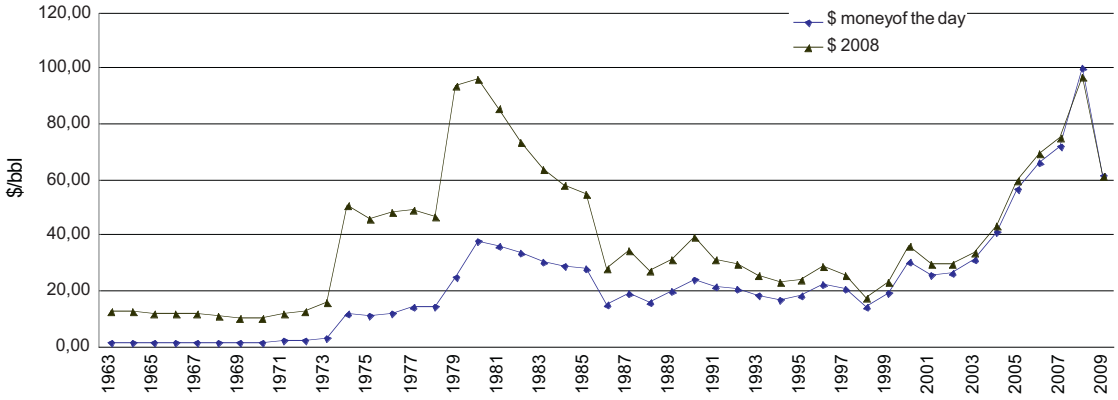
3.6.1. The oil market structure

Having in mind all this, we shall now turn to examine in more detail production and consumption patterns in the oil market. The oil market coordinates activities related to exploration and extraction (upstream area), transportation (middle stream area), and refining, distribution, and retailing (downstream area) at the global scale. In the upstream area, the major players in the global oil market today are: national oil companies (NOC) gathered around the OPEC cartel, eleven NOC outside the OPEC, six private international oil companies, and four private Russian firms [16]. State-owned companies today control more than 80% of world proven reserves [46]. The OPEC cartel produces around 40% of conventional oil and, according to estimates, holds 76% of remaining reserves out of which Middle East countries account for 61%. Here we have to emphasize that, since the seventies the OPEC has been the only group of producers disposing with spare capacity and thus influencing

[12] From the social consciousness of this process of continuous innovation arises the popular and almost unquestioned belief that modern economies will always be able to overcome recurrent environmental constraints.

[13] By effectively I mean that markets consistently provide most of socially demanded goods and services.

[14] As I argued in detail elsewhere [43,45] capitalist economies possess intrinsic, built-in instabilities, which materialize as business cycles and in power-law distribution of size of recessions.



Source: [9] for period 1963-2009, and [17] for the year 2009.

Fig. 2. Oil spot prices 1963–2009 (annual averages).

the global price of oil [16,56]. Therefore, on the supply side we have an oligopoly situation which is under considerable influence of political factors.

On the demand side, there are diverse users: from state oil reserves and petrochemical industry to individual car owners. Major importers of oil are the United States, Japan and China accounting in total for 41% of world imports and 24% of the world production in 2006 [31]. Considering the structure of oil demand by sector we can reasonably conclude that demand for oil is quite inelastic to price increases[15] and that major potential for adaptive change lies with the major user – the transportation sector. During the period 1981–2008 the world consumption of oil increased by 41% while emergent economies like China and India increased their consumption five and four times, respectively. The Middle East economies turned increasingly into consumers of their black gold: at the end of the above mentioned period their consumption was higher nearly three times.[16] The first sharp decline in OPEC's spare production capacity happened in 1980, and, after a period of recovery during the 1990–2000 decade, it occurred again in 2005. Rising world demand for oil and dwindling spare production capacities are confronted with the fact that new crude oil discoveries have been declining since 1963, and the level of discoveries in 1981 was never exceeded in the subsequent years [16].

To wrap it up: the world oil market is dominated by an oligopoly (the OPEC cartel) in which political considerations are mixing increasingly with the purely economic [39] and where the resource being traded is showing clear signs of irreversible scarcity in face of its rising demand on the global scale.

3.6.2. The oil price dynamics

Having examined the basic characteristic of the oil market, we can now turn to oil price and examine what kind of signs we can discern from its dynamics. Oil price dynamics results from complex interaction of many variables, which can be roughly divided into two groups, depending on duration and persistence of their effects: the short term and the long term group. In the short-term group, we account political events like Yom Kippur war, bad weather like hurricanes in Mexico Bay, fluctuations in the exchange rate of US dollar, oil reserves fluctuations in the United States, OPEC's decisions on changes in output, and the phase of the business cycle in the G8 group. In the long term group, there are the so called fundamentals: extraction capacity in the oil exporting countries, production costs, global growth of GDP, and, finally, the physical availability of crude oil. Gasoline taxes and subsidies to oil industry are relatively stable across time but can be changed overnight if necessary so they stand in-between the two groups.

While oil was in oversupply, and this situation prevailed until the end of the 20th century, its price was always defended by some entity which held market power: from Standard Oil (1870–1911), Texas Railroad Commission (1931–1971), until OPEC, which took over the control in 1971 [16]. Except for political-instability driven sharp but short-lived price hikes in 1973 and in 1989 (the Arab oil embargo and Iranian revolution, respectively), the average annual oil prices kept within a narrow band below 20$/bbl until 2000; when an upward-moving trend formed and endured for eight years (see Fig. 2). According to Hamilton [24] there are three key causes for this escalation in oil price: low price elasticity of demand, strong growth of demand from China, Middle East, and other newly industrialized economies, and the failure of global production to increase. Downey [16] points that starting from 2005 OPEC lost its power to manipulate its spare capacity to influence prices because its production could not keep with the growing global demand led by China. To the above mentioned causes contributed many factors such ad the years of under-investment in extractive capacity and refineries during the period of declining prices in the mid-eighties; declining oil supply from non-OPEC producers; the weakening US dollar; political

[15] See Hamilton [24] for estimate of price and income inelasticities.
[16] Calculations based on data from British Petrol [9].

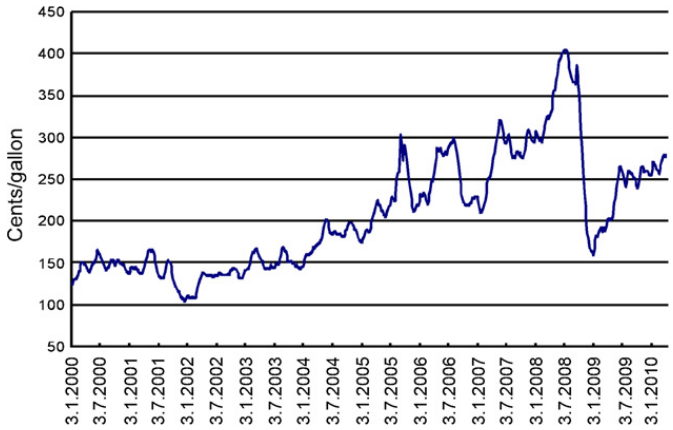
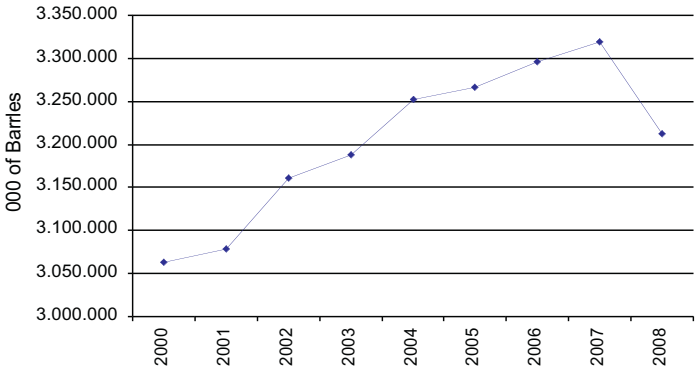


Fig. 3. US gasoline prices: 2000–2010.
Source: [18].



Source: [19].

Fig. 4. Motor gasoline consumption in the US: 2000–2008.

instability in the Near East which entered in a new phase with the Iran's nuclear program; and to a lesser extent speculations in the oil futures markets. It is clear that this decade-long trend of rising oil prices originated from multiple causes which intertwine in a complex way, making thus prices highly volatile and unpredictable.

How did consumers respond? In the US, consumers and car producers did not show signs of adaptive response during most of the price increase period which started in 2003, when oil price averaged $30/barrel and the nominal price of motor gasoline averaged 1.36/gallon[17] (see Figs. 4 and 5). Throughout the period 2000–2007, motor gasoline consumption increased at an average rate of 1%, only to decrease by 3.2% in 2008 when gasoline prices briefly crossed over 4$/gallon (see Fig. 3). This clearly shows price inelasticity of consumer demand up to a threshold range between 3.5$ and $4/gallon when sign of adaptations began to appear.[18] In 2008, when prices started approaching $4/gallon, media reported signs of change in consumer behavior across the US: commuters started switching to public transport or using carpooling, they significantly reduced their purchases of large fuel-inefficient cars like SUV's and traveled 4.4% less miles [63,65]. Public opinion surveys showed that 71% of adults seriously considered purchasing fuel-efficient car in the future, while 66% of them reported cutting back on driving.[19] However, the period of threshold price range lasted extremely shortly and with the onset of financial crisis and global recession, gasoline prices plummeted close to 1.5$. After the oil price recovered, motor gasoline prices rose and fluctuated around $2.5/gallon from 2009 to 2010.

Consumer psychologist Kit Yarrow labeled the price of $5/gallon, the "tipping point" which is expected to trigger major changes in consumer behavior and "re-conceptualize the role of transportation in their lives" [19]. Rubin and Tal [49] expect to see "quantum shift in driving behavior in America" at $6–$7 per gallon – a shift that would bring their driving habits closer to that of Europeans. In the period 2000–2008, motor gasoline prices followed oil prices with strong linear dependency

[17] Data source: Energy Information Administration, 2008. Table 5.24 Retail Motor Gasoline and On-Highway Diesel Fuel Prices, 1949–2007. http://eia.doe.gov.

[18] Hughes, Knittel, and Sperling [29] quoted in [24] estimated that short-run gasoline demand elasticity was in the range of −0.034 and −0.077 for the 2001–2006 period, much lower than in the period 1975–1980.

[19] CNN/Opinion Research Corporation Poll. June 4–5, 2008. $N = 1035$ adults nationwide [53].

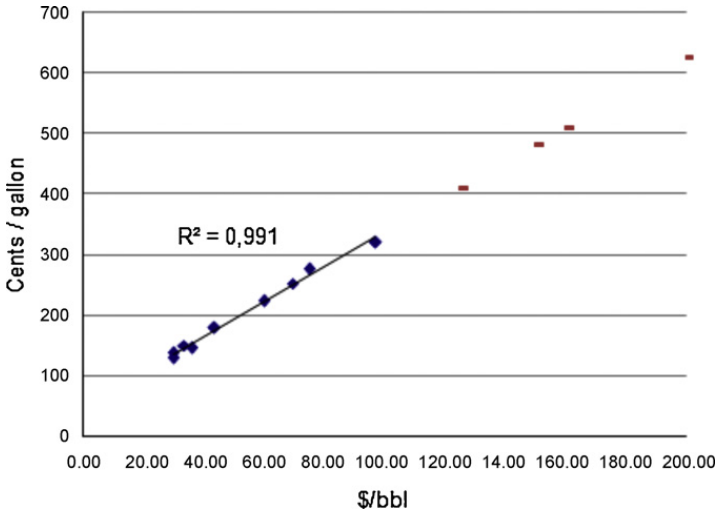
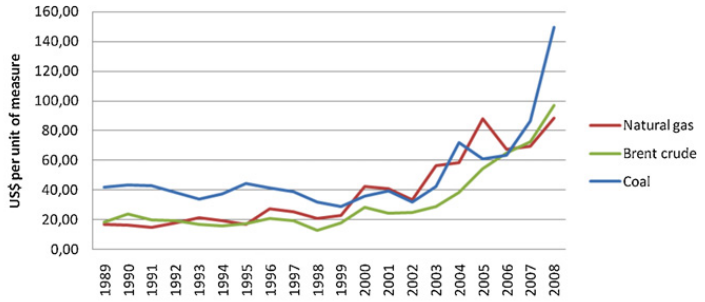


Fig. 5. Estimate of oil and gasoline threshold prices.



Source: [9]. Oil refers to Brent spot; coal refers to Northwest Europe marker annual averages; natural gas refers to NYMEX Henry-Hub natural gas spot price. Units of measure are: oil=bbl; coal=ton; natural gas million Btu (in the figure rescaled in million Btu x10).

Fig. 6. Crude oil, natural gas and coal prices: 1989–2008.

($R^2 = 0.99$) (see Fig. 5). Assuming that strong linear relationship would continue in the future, a simple regression analysis shows that oil price needs to reach the level of 150$/barrel in order to support gasoline price in the range of 4.8–5.10$/gallon, while an oil price of 200$/barrel is necessary to drive the price of gasoline in the range of 6–7$/gallon.

Finally, we have to point to the correlation between the price of oil and two major fossil fuels used to generate electricity or power industrial processes and household heating. World prices of coal and natural gas have been closely matching the rise in price of oil over the past ten years with Pearson $r^2 = 0.91$ and 0.89, respectively (see Fig. 6).[20] This fact is important for taking comprehensive policy measures, as will be shown in the second scenario.

4. Scenarios

When dealing with complex systems, like a socioeconomic system, we are forced to apply multiple perspectives if we wish to capture, and even then only partially, its internal workings and dynamics. Building scenarios is one of the tools that help accomplish this task. Several, recently published works offer a variety of scenarios related to peak oil [27,33,39,57] and to energy transition in general [4,15]. The common message that these different perspectives propose on possible futures is that in any case our lifestyles will be different from today. Secondly, there are many viable futures that we would certainly wish to prevent to happen.

In the present work, I follow the logic of the model introduced in Section 2, and, especially, the specification hierarchy {worldview dynamics {institutional dynamics {economic dynamics}}} which places worldview as the key independent

[20] It is well known fact that prices of most commodities tend to move in the same direction. Because oil happens to be "the commodity" of modern industrial civilization we can reasonably conclude that it is the price of oil that drives that of coal and natural gas prices and not the other way around. This fact has profound implications for any policy that wishes to stabilize and then reduce greenhouse emissions.

variable in the three scenarios. I also assume that peak oil has not occurred yet, so that possible changes in the worldview may actively lead major global economies in an adaptive direction to the post-oil civilization. Conversely, as the model suggests, an unexpected occurrence of peak-oil (an abrupt change in boundary conditions) would force our dominant worldview to change, but this would catch the world completely unprepared – and this is exactly the situation that we would like to avoid (see scenario 1).

The Western worldview that underlies all contemporary capitalist societies is based on individualism, hard-wired work ethic, materialism and rationality with a particular emphasis on "economic rationality"[41]. Economic growth and an ever rising material standard of living appear as one of its most powerful symbols.

Finally, I will consider change in the worldview in two large subsets of the world economy which, anyway, account for most of world energy and resource consumption: The Western group (the European Union, the United States, Canada and Japan) on the one side, and China and India as fastest growing economies with more than 2.5 billion population, on the other.[21]

4.1. Business as usual scenario

In this scenario there is no change in the dominant worldview: two groups put absolute priority on economic growth; consumers in the Western group keep their old habits and preferences while few hundred millions of consumers in China and India pursue intensive Western consumption lifestyles. The overall attitude towards energy transition of political leaders and of the majority of voters is best described as "ready to save the world – but not yet."[22] However, markets agents do perceive that conventional oil is close to being irremediably scarce and they place their bets accordingly. Therefore, the price of oil shows volatility similar to that we experienced in the period 2007–2010, and the world economy flips from expansion to recession on a shortened business cycle. In order to secure enough of relatively cheap energy to fuel economic growth, the US and Canada governments allow off-shore drilling and exploitation of previously protected areas in Alaska, regardless of huge ecological risks and despite protests of environmentalist. In South America, more and more of the protected areas of the Amazon rainforest are rented to Chinese and US companies for oil drilling. Besides pushing out the US companies from some South American oil exporting countries, China continues its oil expansion in Africa and, eventually, takes control of the majority of its oil reserves, at the expense of Western oil companies. Old tensions over the rights to off-shore oil and gas drilling in the South China Sea between China on the one side and other members of ASEAN and the US on the other, reaches a stage near to an armed conflict. At the same time, the US and Russia enter an open contest for oil exploitation in Arctic. After the failure of military intervention in Iraq and the withdrawal of US forces and its allies, Middle East countries remain largely in control of oil extraction and adapt its dynamics to the current swing in the world business cycle. Their long-term extraction strategy is "resource pragmatism": preserving enough of the oil consumption years for the benefit of their economies and thus keeping the rate of output well behind its maximum potential [39].

Besides allowing for drilling in environmentally fragile areas, which temporarily drives down oil price and increases overall supply to the world market, governments in both groups increase the subsidies to oil industry and especially so in times of recession in order to stimulate transport industry and personal consumption. In the absence of steady and reasonably high oil price, consumers and industry are confused. Industry does not have a stable horizon for investment in new products and technologies that would go beyond dependency of oil. Consumers hesitate to change their long-established habits and, consequently, their demand does not stimulate industry for a major change in its output.

Driven by West's unhampered demand for consumer goods, China becomes world's major economy in terms of throughput. The accumulation of economic wealth, directly and indirectly controlled by its undemocratic government, has been partially used to build a military power that makes it second only to the US. India does not manage to impose itself as a political or military force in the global contest for oil. However, its economic growth and increasingly Westernized life-styles contribute significantly to global demand of oil. On the other, its addiction to fossil fuels makes this overpopulated and ethnically diverse economy politically extremely vulnerable on peak-oil crisis.

Eventually, the world faces the change in boundary conditions where it is no longer possible to increase oil production form neither conventional nor unconventional sources. In fact, the use of unconventional oil to keep the price of oil relatively low (in the range of 70–150$/bbl) has already depleted the best part of this, "auxiliary" or "second choice reserve". Therefore, the shape of the world oil extraction looks very similar to that of the Hubbert's curve: relatively sharp peak and a steep decline. Faced with changed boundary conditions, the dominant worldview in the Western group necessarily changes, but there is no longer time for a well-thought and gradual adaptation of capitalist institutions to new circumstances. Technologies that could have helped the energy transition period have not been developed yet or are only in its early stages. In the meanwhile, major world economic and military powers have reached a high level of political tensions – a result of years of competition for control over the remaining oil fields. The world enters a rapid process of de-globalization and economic depression. High energy prices coupled with the loss of their export markets in the West triggers deep political crisis in China and in India. Disturbingly enough, Western democracies find themselves exhausted

[21] Both groups count about 3.5 bilion people, or nearly 50% of the current estimate of the world population of 6.8 billion.
[22] This is the title of the comment in Financial Times after the failure of climate talks in Copenhagen [13].

by recurrent recessions and economic insecurity, which at the times of final oil-crisis opens space for voting extreme political options that promise "fast and fair" solutions.

4.2. Western group leads the process of change

Somehow, the long ago sown seeds of Western environmentalism, the fear of consequences of climate change, and the growing public awareness that our life styles are not sustainable, trigger a significant change in the socially shared worldview in the Western group. The majority of its population seeks to re-establish emotional ties and unity with nature and adopt a new system of values, which constituents were already present in the environmentalist ethic and in the new age of sub-culture. Simultaneously and congruently, the values that support conspicuous consumption and long working hours give way to those that underpin socialization, community work and personal development. That change permits to uncouple people's well-being from the consumption of goods and services and to trade part of their potential incomes for leisure and unpaid activities.

The shift in the worldview in the Western group brings to power Green parties which initiate a process of *institutional changes* with the goal to adapt to post-oil era. In fact they follow recommendations of the Hirsch report from 2005 which urged to act well before the problem is obvious. Their governments introduce jointly an oil tax – a measure that has been proposed earlier in the US [35,36]. By taxing oil policymakers achieve contemporarily three systemically interrelated goals with the same fiscal instrument: (1) increase the price of gasoline and other oil derivates to induce major changes in the transportation sector; (2) push up prices of coal and natural gas, with the goal to increase the price of electrical energy and thus stimulate energy efficiency and conservation at all consumption levels in the economy. Policy makers understand that raising the overall price level of fossil fuels is indispensable if they want to stimulate industry and households to reduce greenhouse emissions. By increasing the price of electricity and thus reducing the overall demand for energy, policy makers respond to yet another constraint which was pointed at earlier by scientists [38,60,62] – that renewable sources of energy – solar, wind geothermal and biomass cannot be increased enough to substitute demand for energy from fossil fuels.

At the same time policy makers remove subsidies from the oil industry which have been distorting for long time the real cost of production. By introducing an oil tax and by eliminating subsidies, governments achieve the crucial goal of keeping the national energy prices high and relatively stable, with the oil price in the range of 170–200$/bbl. This measure is required in order to secure a degree of macroeconomic stability, which is necessary for adaptive processes to take momentum in the economy.

Government funding is provided for primary research in the energy sector and for improvements in new technologies like smart energy grids and development of new generation of nuclear power plants. The subsidies withdrawn from the oil industry are transferred to solar industry boosting the demand for solar panels in the household sector. As a single largest buyer in a national economy, governments make active use of their procurement policy to increase demand for specific products and technologies that are supporting the process of energy transition.

Having received clear demand signals from the consumer side and government procurement, and having a stable energy price horizon, the industry introduces new products and technologies at a pace that was impossible in the earlier period. The Western group emerges as a world leader in many areas that are relevant to post-oil era like solar and wind technologies, energy efficient housing, and mass urban transport.

Initially, the government decision to increase the price of oil and electricity triggers a long recession which causes a stream of institutional changes necessary for economy to adapt to new constraints. In order to fight high unemployment at home, governments walk away from the WTO and return to bilateral trade arrangements, actively using duties and taxes to stimulate selected domestic manufacturing sectors. This reduces significantly the volume of international trade and changes its composition. Globalization process breaks down and production of food and many basic consumer products turns local again. Because of high gasoline prices, individual transport shrinks as well as the car industry, which this time receives no bailout from the government. After the crisis of the prolonged recession, the economies embark on a process of de-growth[23] by reducing the excess productive capacity which is no longer needed in a society that have to a large extent rejected consumerism. This process further reduces employment in industry, but also in service sectors like tourism. To cope with this problem, government reduces working time to six hours and three to four day working week, depending on industry. Besides this institutional change, new employment is created in services that support recycling, reuse, and repair of products, now that mass production have been reduced to suit new life-styles.[24] On average, the individual material standard of living returns to that of the Sixties of the 20th century in prosperous European economies or in the US. This time, however, it is supported by much more advanced technology.[25] The Western group successfully manages to reduce economic activity without destroying markets and undermining democracy.

Faced with de-globalization process China and India are forced to redirect their economic activity to cover the needs of their own populations. Because the Western group has been reducing yearly their imports of oil, its world price has not

[23] For details on ideas on de-growth see Latouche [34], Bonaiuti [8], Filipo and Schneider [22] and Odum and Odum [50].
[24] This effectively means the materilization of the old 4-R concept: reduce, reuse, repair, recycle.
[25] The idea that the material standard of living in industrialized economies should return to the level of Sixties is form Latouche [34].

been prohibitive for their economies to keep growing and lifting from poverty large strata of their populations. The absence of fierce competition for remaining oil fields with the Western group eased political tensions with China which initially arose after the Western group decided to withdraw from WTO and closed their borders for many of previously imported products.

The Western Group opposed strongly exploitation of conventional oil, tar sands and oil shale in Alaska, Amazon rainforest and other ecologically fragile areas. Eventually, Middle East exporters started decreasing their yearly output, and the world entered the peak-oil crisis. At that point the Western Group was ready to absorb the shock and had both institutional and technological means to mitigate its impact. They were ready to share their know-how with other countries. The world economy was already less interdependent and thus less vulnerable to oil shock. As the peak-oil crisis developed, China entered in an internal political turmoil. At this bifurcation point in world's history, its future course is to a large extent depending on political choices of China's non-democratic government.

4.3. Global governance

The change of worldview initiated in the Western Group is soon accepted in China and India who understand that the conventional Western model of development is not sustainable and that they are building their economies on the foundations of sand. An international convention of major oil exporters and oil importers, inspired by the Oil Depletion Protocol [10], stipulates the twenty year long plan of deliveries and prices which start from 150$/bbl and are thereafter increased on a yearly basis by a certain percentage. The oil is thus withdrawn from market vagaries, and industries and consumers all over the world have a stable horizon for long term investment or buying decisions. The convention takes into account different levels of economic development and to countries that need to pursue economic growth to eradicate poverty grants special, lower prices and increasing instead of decreasing yearly deliveries of oil. The convention signatories agree to form a global fund for development of renewable energy technologies.

Major global economic players agree to abandon WTO and revert to bilateral international trade in order to have individual maneuver space to manage their economies in the energy transition and de-growth processes. This leads to de facto de-globalization, but leaves no resentments. However, the international community reaches a major West-South cooperation agreement that enables quick and free transfer of technologies and know-how, which are necessary to mitigate the energy transition period.

After several decades, world economies are no longer dependent on oil although oil is still used in chemical industry, and national reserves are kept for emergency or special purposes. The average material standard of living in the world has decreased because industrialized countries reduced their material and energy per capita consumption. Southern countries embarked on different kind of development and made important progress in eradicating poverty.

5. Conclusions

The world energy situation in the 21st century has invariably changed and we can identify it as a ''new energy order'' that calls for major international cooperation and global governance of resource scarcity and environmental problems as indicated by Bilgin [4]. The present work, within this context, offers a systemic perspective on alternative transitions to post peak-oil futures. It is based on the model that accounts for a causal relationship between a dominant worldview in a society and the societal choice of technology and institutions, which then constrain and direct dynamics at the level of production and consumption. Three scenarios emerged consequently:

The *Business as usual* scenario provides an idea as where the world might be heading under the assumption of a myopic and unchanging worldview.

The *Western group leads the process of change* scenario describes an evolutionary cascade of change in the Western group, which starts with a substantial change in the dominant worldview. This substantial change does not entail a revolution. Although its institutional solutions appear very challenging today, they do not necessarily stand out of the capitalist democracy.

Finally, the third scenario is about *global governance* – a future that offers least unknowns and least threats to the Western civilization and to the world as a whole. It is up to readers to assess how far we are today from this desirable alternative future.

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