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PEAK OIL

– A study of the phenomenon and possible effects and alternatives in Finland

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PEAK OIL
– A STUDY OF THE PHENOMENON AND POSSIBLE EFFECTS AND ALTERNATIVES IN FINLAND

This thesis studies a phenomenon called oil peak; what does it mean, what are the possible effects and consequenses in Finland. The theoretical framework covers facts about oil and energy, different theories from microeconomics all the way to different oil theories. It provides comprehensive information on the subject.

The empirical research includes two separate expert interviews with the aim of understanding peak oil and its effects in Finland from two different perspectives. The other expert coming from from private sector and the other expert from public sector. The research was conducted by using qualitative method and the questions were made mainly based on the theoretical framefork.

Main findings of this study were that peak oil is recognized but experts still argue what does it mean practically; when is it going to happen or has it already happened. The era of cheap oil is coming to an end and it is time for Finland to investigate all possible solutions which could decrease our level of oil dependency.

KEYWORDS:

Peak oil, oil dependency, oil crunch, eroei, energy, alternative energy, energy in Finland, oil theory, energy production, energy consumption

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ÖLJYHUIPPU
– TUTKIMUS ILMIÖSTÄ JA SEN MAHDOLLISISTA VAIKUTUKSISTA JA VAIHTOEHDOISTA SUOMESSA

Tämä opinnäytetyö tutkii öljyhuippua ilmiönä; mitä se tarkoittaa ja mitkä ovat sen mahdolliset vaikutukset ja seuraukset Suomessa. Teoreettisessa viitekehyksessä kerrotaan öljystä ja energiasta, eri teorioista aina mikrotaloudesta öljyteorioihin. Se tarjoaa kattavat tiedot aiheesta.

Tutkimuksen empiirinen osuus sisältää kaksi erillistä asiantuntijahaastattelua tavoitteena ymmärtää öljyhuippua ja sen vaikutuksia Suomessa kahdesta eri näkökulmasta. Toinen asiantuntija tulee yksityisen sektorin puolelta ja toinen julkisen sektorin puolelta. Tutkimuksen toteuttamisessa käytettiin kvalitatiivista analyysia, ja kysymykset pohjautuivat suurimmaksi osaksi teoreettisessa viitekehyksessä käsiteltyihin asioihin.

Tutkimuksen tärkeimmät havainnot olivat, että öljyhuippu tunnistetaan, mutta asiantuntijat ovat eri mieltä mitä se tarkoittaa käytännössä; milloin se tapahtuu vai onko se jo tapahtunut. Halvan öljyn aikakausi on lähenemässä loppuaan, ja Suomen on tutkittava kaikkia mahdollisia ratkaisuja öljyriippuvuutemme vähentämiseksi.

ASIASANAT:

Öljyhuippu, öljyriippuvuus, öljyshokki, eroei, energia, vaihtoehtoiset energialähteet, energia Suomessa, öljyteoria, energian tuotanto, energian kulutus

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LIST OF ABBREVIATIONS (OR) SYMBOLS

EROEI = Energy return on energy invested

OPEC = Organisation of the Oil Exporting Countries

TW = Tera Watt

TWh = Tera watt per hout

PV = photo voltic

AD = Anno Domini

Gb = Billion barrels

LNG = Liquid Natural Gas

CO2 = Carbon Dioxide

FED = Federal Reserve System

Tj = Tera joule

1. INTRODUCTION

In this Thesis we will be addressing the subject of peak oil and what possible consequences it will have in Finland as a nation. We will study what are the main sources of energy for Finland at the moment and in the future.

The target of this thesis is to study the peak oil phenomenon and its consequences and what possible alternative energy sources there are available for Finland now and in the future. Also we will research the tradeoffs of these energy sources.

In this Thesis we are going to collect data from reliable online sources and books. We will also conduct two expert interviews on the subject.

The structure of the thesis will be built as so:

First we will collect data on different aspects of peak oil and try to find the most up to date information as possible to get a fresh research with hopefully new information on when the peak of oil production will happen, how it is affecting us today and what it means for us in the future. We will look for data on how oil production and consumption have evolved in the past and how it is predicted to evolve in the future. This data should give an understanding on what situation we are really in at the moment and give a base for the next section of the thesis.

In the second section of the thesis we will focus more on what the Energy situation is in Finland at the moment. We will also study the alternative resources and what could be the best alternative energy sources for Finland. What might be the most promising future fuel prospects and what means of action are taken by the government to insure Finland's energy availability and stability.

We will use qualitative research methods to gain an understanding on the subject.

1.1 Research Questions

Research Question 1: When will peak oil happen and what consequences will follow?

Research question 2: What effects will the peak oil phenomenon have in Finland and what are the alternatives?

1.2 About Oil and Energy

The price of oil has been historically volatile in the last 10 years as there has been record breaking prices over 140 dollars a barrel in July 2008 down to 30 dollars/barrel in December 2008 as the “credit crunch” hit the market demand. Now after the initial shock of the credit crunch is over, prices have soared back up to a maximum of over 120dollars a barrel and the fluctuation has kept on going on rapidly as markets are hesitative over everything. Even before 2008 record oil prices there where at least 7 significant spikes in volatility with first topping out in 2002 (Moneyweek Ltd 2012.)

The threat of a nearby oil shortage and financial uncertainty has sparked discussion on how nations should prepare for the upcoming “oil crunch”. Discussions have started to demand more effort into developing and implementing alternative resources as soon it will be too late. “There are two challenges for governments and policy makers. Firstly to recognize the situation and secondly to take action to mitigate the worst implications of the crunch.” (The Oil crunch – ITPOES, 2010, 4).

The issue that has got more media and political attention is climate change. Climate change is easier to approach from a political point of view as co2 emissions are not the fuel of the economy we run, it is just the pollution that comes out. Making systems more efficient is a good and necessary thing we have to do but as long as growth is the measurement of success which everyone is trying to get, making things more efficient will slow things down but it won’t stop the problem.

Cutting emissions is a good start combating what is ahead of us, but it is just reducing the symptom instead of fighting the disease
In the fight against climate change many countries have signed climate change treaties. One of the main treaties was the UNFCCC treaty with a goal of achieving stabilization of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This treaty first signed in Kyoto Japan, in 1997 has started a need to invest in more alternative energy sources and more efficient technologies. (U.N. 2012.)

Renewable energy is often seen as answer for the compensation of fossil fuels. Renewable energy in 2010 was 16,7% of global final energy consumption counting traditional Biomass, hydropower, wind, solar, geothermal, modern biomass and biofuels. Out of the 16,7% of energy, traditional biomass which is used for conventional cooking and heating in rural areas accounts for approximately 8,5% of the total renewable energy share. Modern renewable energy accounts for approximately 8,2%. Modern renewable continued to grow strongly in all end use sectors. (Ren21, 2012, 13.)

We have chosen to investigate how the price of crude oil effects investment and implication into renewable energy in Finland and how peak oil will effect the transition to renewable resources and what measures could be taken into action to speed up the process. We want to find out if it could possible cover the energy loss Finland will face when oil will be much more expensive, what would be the best option of energy source Finland could use and when would be the best time to start the transition.

1.3 Purpose

The purpose of this study is to understand the phenomenon peak oil in Finland by investigating Finnish experts and the general opinion on its realization and its effects. We want to gain a deeper understanding of the subject and find out the views and possible scenarios.

1.4 Limitations

This study will be conducted on Finland because it is the country we live in and data is easily available to us. Finland is also an interesting country because Finland imports most of its energy from abroad so it will it that sense be strongly affected compared to its neighboring countries Sweden, Norway and Russia. Norway and Russia are both oil exporters and Sweden is has started a transition program already in 2006 to significantly cut down oil dependency by the year 2020 and plan to have 50,2% of total energy consumption to come from renewable energy sources. In 2010 Sweden’s share of renewable out of total consumption was 47,9%.(Eurostat, 2012, 1-2.)

Another limitation to this research is that the peak oil theory is still argued and it has not been accepted by everyone. Especially many oil industry representatives such as the President of The Royal Dutch Shell`s US operations John Hoffmeister, while agreeing that conventional oil production will soon start to decline he points to the large reserves at the U.S. outer continental shelf, which hold an estimate of 100 billion barrels of oil and natural gas. As things stand, however only 15% of those reserves are currently exploitable. Hoffmeister also mentioned that most calculations so not include unconventional sources such as the oil sands of Canada, and the oil shale in the rocks of Colorado, Utah and Wyoming.(CNBC 2008)

This Thesis will focus on the perspective that peak oil has happened already or is going to happen in the near future and there will not be any new revolutionary source of energy discovered.

2. PEAK OIL

Peak Oil is the point when the maximum rate of oil extraction is reached and the depilation starts. After production hits its peak it starts its terminal decline. Every oil well features these same properties. After reaching the maximum level of production more effort is put in to get the same amount of oil.

The theory was first proposed for the first time by M. King Hubert in 1956 to the American Petrol institute as an idealized symmetric curve. The curve is the main component for Hubert's peak theory, which has led to the rising peak oil concerns.

"The amount of crude oil is dependent on the amount of effort put into its production. If the production levels stay the same over a given period of time, but efforts increase, then the productivity has actually decreased, which was what happened between 2005 and 2010 when upstream investments where doubled." (MW & H2O Magazine, 2012, 36-38).

Perceiving the depletion of oil production is hard because there are only approximate estimates available and indefinite information. First of all you have to define what you should measure. There are many different types of oil and gas, which prices vary according to how easy or hard, how fast or how slow they are to get into use. For example a oil well in the Middle East can produce 50000 barrels a day just on its own weight when as in Canada they suck bitumem out of oil sand using highly advanced technology.

There are different kinds of oil types and gasses ranging from traditional crude oil to refinery produced natural gas. Crude oil by any measure is still the most important and widely used which is why predicting gross production is possible. (Bovet etc. 2008, 18.) In the first part of this study we will not be counting unconventional oil sources like Canadian oil sand, Venezuelan Bituminous resources or Rocky Mountain oil Shale. Even though there is plenty of oil in these sources they are not counted in because production from these sources is still very small as they are very expensive to produce and or do not have large scale ready production infrastructure.

The importance of oil for our modern society is staggering. It is one of the bases for a welfare society. The applications for oil are endless for example. transportation, food and agriculture, heating and cooling, medication, information storage and transmission. Ever since the green revolution that happened in the 1950`s the world agricultural production greatly increased multiplying the world population. It is obvious that a terminal shortage in oil supply will have drastic effects. The OPEC Oil embargo in 1973-1974 and oil shortage caused by political basis can be looked at as a warning of a sudden price shock and shortage.

“Until Recently OPEC assured the world that oil supply will be plentiful, but that position is changing. Some in OPEC countries are now warning that oil supply will not be adequate to satisfy world demand in 10-15 years.” (Hirch, 2005, 3). Even Dr. Sadad al-Husseini, a retired senior Saudi Aramco oil exploration executive, is on record as saying that the world is heading for an oil shortage. (Hirch, 2005, 3.)

Whilst talking about peak oil, the decline speed of production rates and the speed we are able to compensate the energy loss with alternative energy sources after the peak is crucial to our well-being and economic stability. A strategy has to implement on a national scale to build a new energy infrastructure. Waiting for the market prices to encourage development of a new energy system will be too late. (Heinberg, 2003, 98.)

2.1 The origin of Oil

The dominant understanding in where oil came from is that remains of plants and animals (diatoms) that lived millions of years ago in a marine environment eventually got covered under layers of sand and silt. Heat and pressure from these layers helped turn these organic life forms into crude oil. To turn into oil these organic life forms have to end up in an environment where they avoid immediate chemical disintegration in other words oxidation. These necessary environments are usually in the oxygenless trenches or sediment pools of seas or lakes. (EIA 2012.)

The sediment pools have to collect more water from outside, than what it lets in so that it can collect minerals and nutrients to sustain organic life. The original organic life forms break up into simpler hydrocarbon chains and ultimately crude oil. The hydrocarbon sediments have to sink to around 2500 meters so that it is possible for them to form oil. Equivalently at about 5000 meters the heat starts to rise so high that the oil itself starts to break down and turn into gas. The final and simplest form of hydrocarbon is methane. Thus 2500m to 5000m comprises the “oil window” where most oil wells exist. The movements of the earth’s crust, like earthquakes can free oil from these wells and oil can rise all the way up to the surface. The sediment layers at the bottom of the seas are usually about 1000 meter, which is why they aren’t favorable for the creation of oil. (Deffeyes, 2001, 21-26.)

2.2 History of Oil

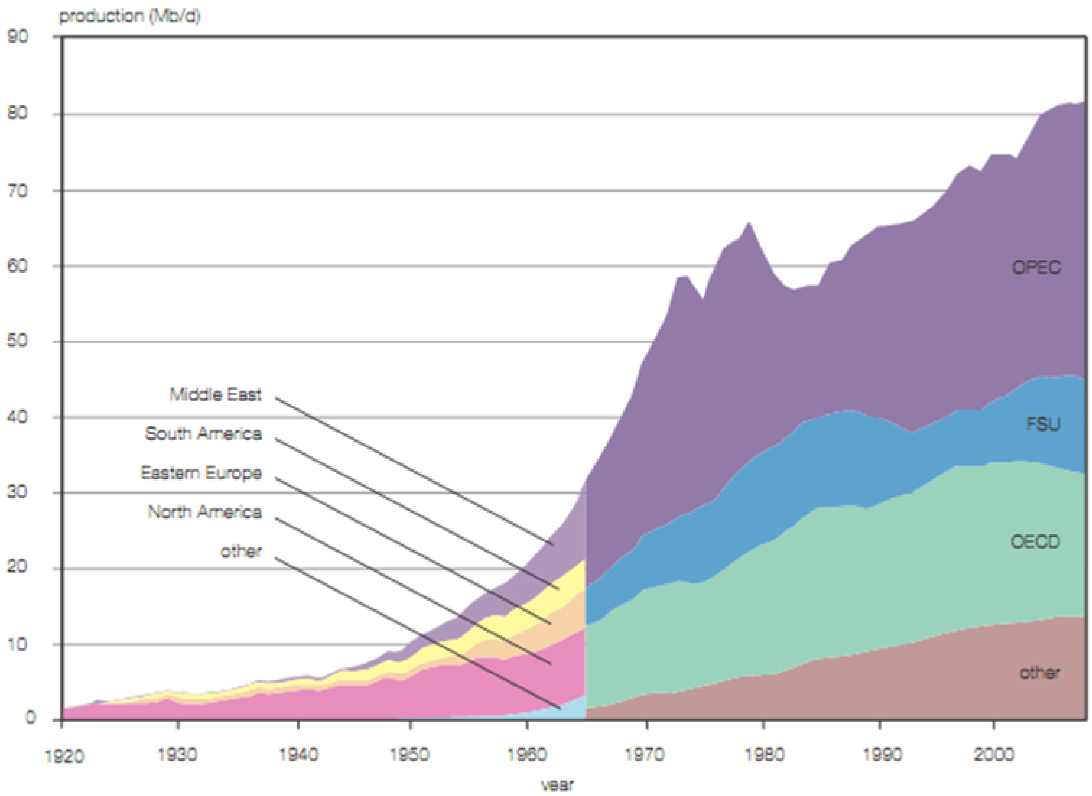
As many other inventions, necessity was the mother of invention. In the 19^{th} century use of motorized machinery proliferated. Vegetable oil, whale oil and animal tallow were typically used for machine lubrication, and whale oil for fuel lamps. As demand grew, whales started to be hunted to the point of extinction and prices rose. As machinery also became more complex and sophisticated Vegetable and tallow oils were proving inadequate. (James S. Robbins, 1992.)

In the late 19^{th} and early 20^{th} century a new energy source was taken into use: Petroleum. Petroleum had been in use in warfare since 670 AD, when Emperor Constantine IV attached flame throwing siphon devices to his ships. The first successful commercial drilling first started in 1859 by Edwin L. Drake in northwest Pensylvania. Petrolium became widely available as a cheap and superior lubricant and when refined into kerosene, as lamp oil. (Heinberg, 2003, 57.)

By 1866 Drake went bankrupt; meanwhile John D. Rockefeller had begun purchasing crude oil. Soon he had the largest refining operation in the US which he named Standard Oil. After a mere decade and a half since its standard oil started in 1865 Rockefeller had practically captured worldwide monopoly on petroleum. Rockefeller's monopoly started to crack when other countries and companies started to come into the business. Russia discovered oil in Baku in 1871 and by 1885 Russian production levels where about one third of US production. During the 1890`s production in the Dutch East Indies (now Indonesia) grew rapidly under the commercial control of the Royal Dutch Company.

With Thomas Edison`s promotion of electric lighting in the 1880`s, demand for kerosene peaked and began to recede. However new uses were invented at a steady pace from oil furnaces to oil boilers for factories, trains, and ships, but by far the most important new use for petroleum was invented by Nikolaus Otto in the 1870`s. Gasoline when first discovered was seen as a dangerous refinery waste product but when put into use in combustion engines it was the perfect fuel to power up engines explosively. (Heinberg, 2003, 58-60.)

In the first half of the 20^{th} century the industrial world`s reliance on coal subsided while its use of oil expanded greatly. Oil reshaped the newly industrial world and had explosive effect. Throughout this time US was in a position to control the world's price of oil. This changes in the second half of the 20^{th} century. More and more oil was being discovered and tapped in the Middle East. Eventually the Middle East overtook the US in oil production and became the world's largest Oil producer. After World War 2 major oil companies began maintaining two oil prices: a domestic price and international price. The price of domestic oil was always higher. This controlled by an import oil embargo for foreign oil.



(Figure 2.2, US Department of Energy for 1920-1964, and BP Statistical Review of World Energy for 1965-2008)

The embargo was repealed in the 1960`s as US consumed more oil than what they produced thus had to start importing oil for consumption. In 1970 Americas rate of oil production in the US peaked and begun a long decline that has continued to the present. From this point on US was more and more dependent on imported oil and was no longer able to control the world oil market price. (Heinberg, 2003, 64-75.)

3. ENERGY AND OIL THEORIES

Supply and demand is an economic model of price determination in a market. It concludes that in a competitive market, the unit price for a particular good will vary until it settles at a point where the quantity demanded by consumers (at current price) will equal the quantity supplied by producers (at current price), resulting in an economic equilibrium of price and quantity.

The four basic laws of supply and demand are:

“

1. If demand increases and supply remains unchanged, then it leads to higher equilibrium price and higher quantity
2. If demand decreases and supply remains unchanged, then it leads to lower equilibrium price and lower quantity.
3. If supply increases and demand remains unchanged, then it leads to lower equilibrium price and higher quantity.
4. If supply decreases and demand remains unchanged, then it leads to higher equilibrium price and lower quantity.” (Besanko & Braeutigam, 2005, 33).

3.1 Hubert`s Theory

Marion King Hubbert was a geoscientist who worked at the Shell research lab in Houston, Texas. He made several important contributions to geology, geophysics, and petroleum geology, most notably the Hubbert curve and Hubbert peak theory with important political ramifications. He was often referred to as "M. King Hubbert" or "King Hubbert".

In 1974, he presented several production curves for both the World and the United States, but was somewhat reticent in explaining the mathematical basis of his work. He referred to a bell-shaped curve, of which the most commonly used are the Normal or Gauss curve, and also to the derivative of the logistic curve but he gave no equations. He based his study on Ultimate Recovery, taking 170 Gb (billion barrels) for the USA; and low cases and high cases for the World of respectively 1350 Gb and 2100 Gb. His initial study concerned the US Lower 48 States, which had a single cycle of continuous exploration in a large number of basins. He referred also to the relationship between discovery and production. The discovery cycle peaked in the late 1930s and was followed by a corresponding production cycle peaking around 1970. But as explained below not all countries are characterized by a single discovery cycle; and there are other constraints to the Hubbert model that need to be better understood. It is to be noted in particular that it is a symmetrical curve whereas the production curve of an individual field is generally asymmetrical. (Laherrère, 2000)

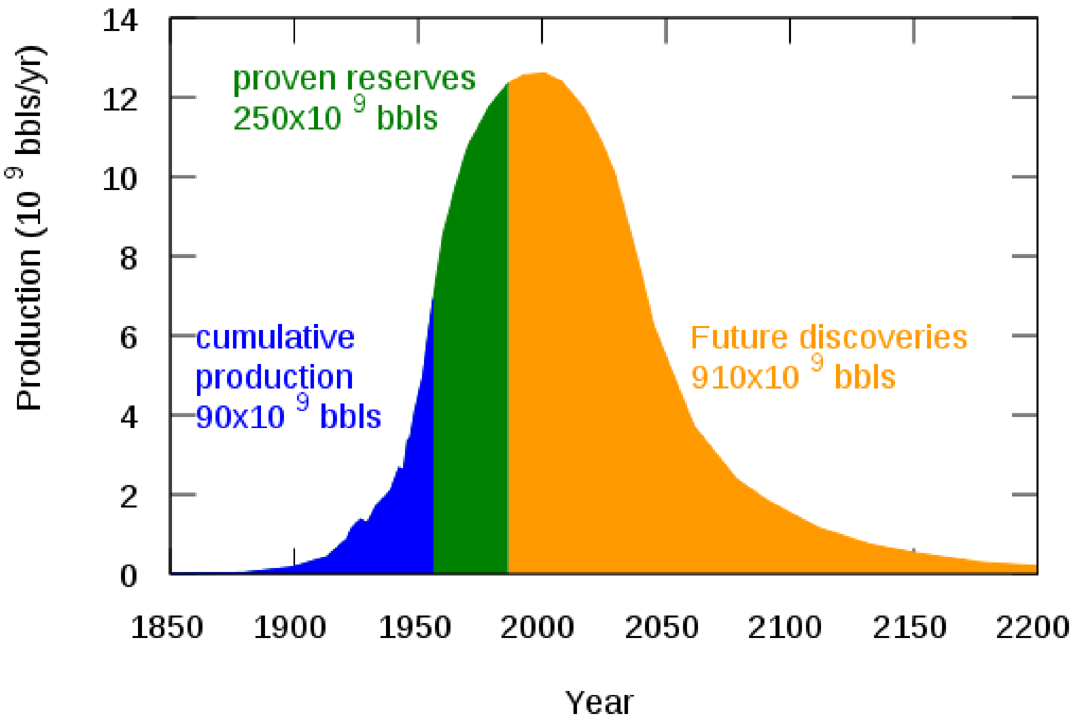


Figure 3.1. A bell shaped production curve, as originally suggested by M. K. Hubert. (Wikipedia 2012).

Central for Hubbert`s Theory on production capacity of fossil fuels is the knowledge that fossil fuel are finite compared to for example wind- or hydropower that renewable resources. After this we can assume that production at has started from zero and will at some point end at zero. At this point the resource has either finished or is worth producing. In the begin production rates start with slow growth until it starts to grow more or less exponentially until it reaches its peak and starts to slow down from where it starts its terminal decline which to some extent is similar to how it has grown.(Miilunpohja, 2010, 23.)

3.2 The Olduvai Theory

Richard C. Duncan has an MS in Electrical Engineering and a PhD in Systems Engineering. He is the main author of the Olduvai Theory.

The Olduvai Theory is based on an assumption that the life expectancy of an industrial civilization is approximately 100 years, from 1930 to 2030. This claim is based on the energy production per capita. So basically this theory states that after a one hundred years energy production per capita will be at a lower rate compared to the previous year(s).

The Olduvai theory suggests four different things:

1. The exponential growth of world energy production ended in 1970.
2. Energy production per capita does not show growth from 1979 to circa 2008.
3. The energy production per capita will contract rapidly circa 2008.
4. World population will follow the downward trend of the energy production per capita. (Duncan, 2005, 1.)

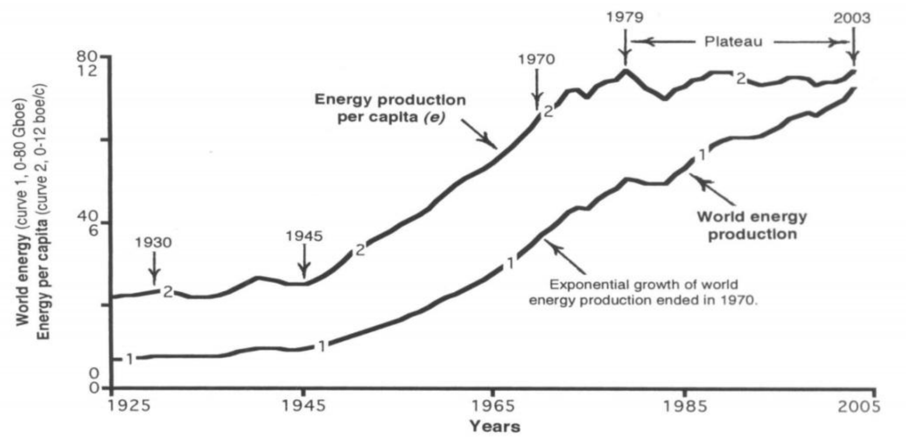


Figure 3.2. “World energy production and energy consumption per capita” (Duncan, 2005, 6).

According to the Olduvai Theory five sources of energy grew exponentially during these time periods as follows:

1. Coal for 209 years: 1700-1909.
2. Oil for 137 years: 1833-1970.
3. Natural gas for 90 years: 1880-1970.
4. Hydroelectric energy for 82 years: 1890-1972.
5. Nuclear-electric energy for 20 years: 1955-1975

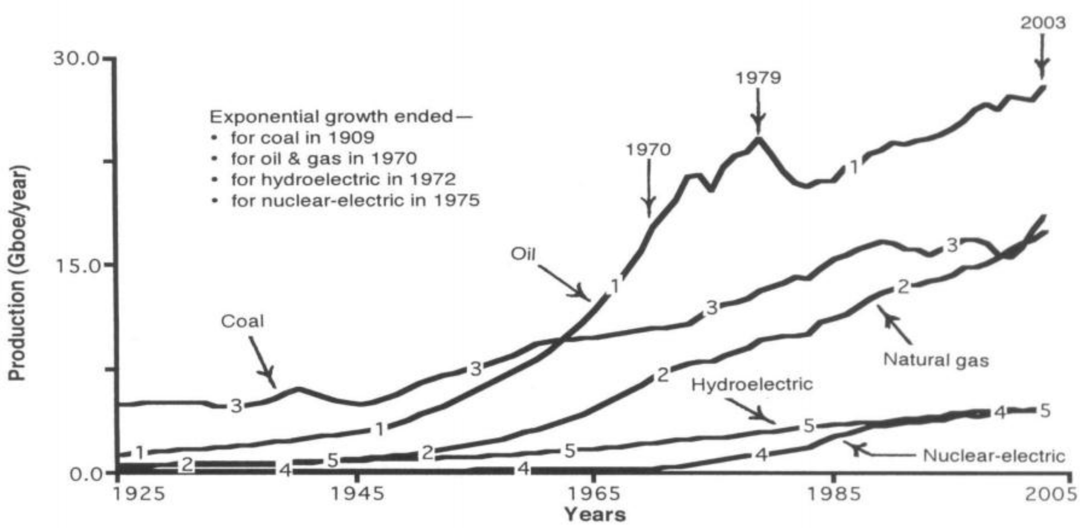


Figure 3.2. “World production of the five major sources of energy. All curves are scaled in ´billion barrels of oil equivalent´ (Gboe)” (Duncan, 2005, 5).

Duncan says that despite of the statistics showed in the figure XX, there is still a possibility that coal and/or nuclear energy could grow exponentially still in the future but that would be only temporary and for a brief time only. Duncan stated that while this is true for these two energy sources it is impossible for the rest; oil, natural gas and hydroelectric energy. (Duncan, 2005, 6.)

The Olduvai Theory discusses seven different events which marks the beginning and eventually the destruction of an industrialized civilization. These events, and the possible explanations to these events, are:

1. In 1930 energy production per capita reached 30%. From 1930 to 1945 the world was in a crisis due to the Great Depression and World War II.

2. In 1945 energy production per capita entered a fast growth period. This correlates with the high production rates of oil and natural gas from 1945 to 1970.
3. In 1970 energy production per capita entered to a period of slower growth. From 1970 to 1979 oil production rates began to slow down.
4. In 1979 energy production per capita became to a standstill, an era of no growth. From 1979 to 2003 world´s population growth was so high that it could keep up with the energy production.
5. The year 2004 marks the beginning of the Brink where energy production struggles with the rising demand.
6. In circa 2008 energy production per capita starts to decline.
7. In 2030 the energy production per capita has fallen to 30% of its maximum level. (Duncan, 2005, 7.)

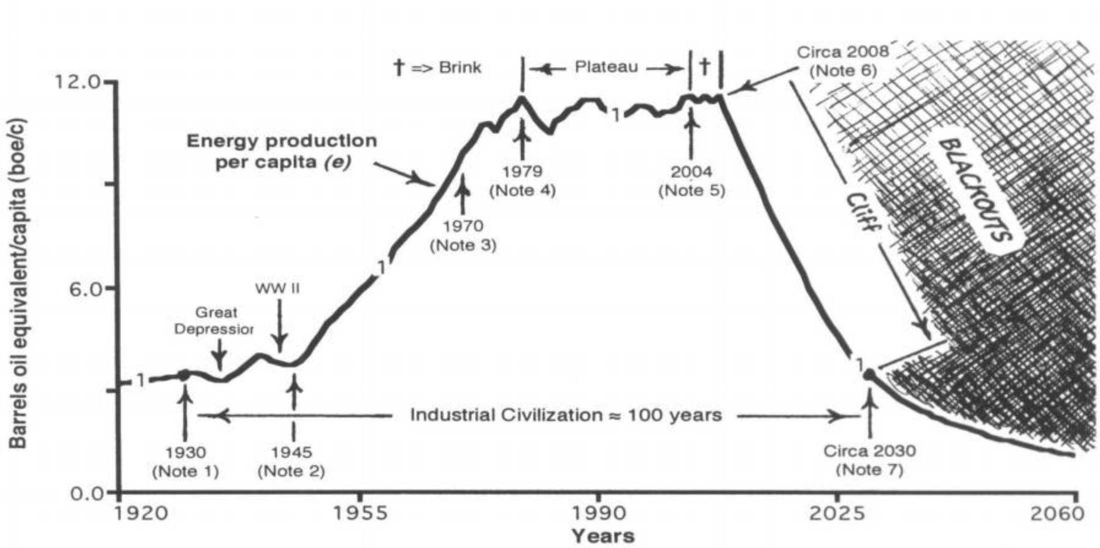


Figure 3.2. “The Olduvai Theory: 1930-2030. Notes: (1) 1930 => Industrial civilization begins; (2) 1945 => Very strong growth begins; (3) 1970 => Growth begins to slow; (4) 1979 => The no-growth “Plateau” begins; (5) 2004 => The “Brink” begins; (6) Circa 2008 => The “Cliff” begins; and (7) Circa 2030 => Industrial civilization ends” (Duncan, 2005, 7).

In the end The Olduvai Theory is about the statement that the life expectancy of industrial civilization is approximately 100 years from about 1930 to 2030 and that there is four main assumptions to go along with that (Duncan, 2005, 10.):

“

1. The exponential growth of world energy production ended in 1970.
2. Average energy production per capita will show no growth from 1979 to circa 2008.
3. The rate of change of energy production per capita will go steeply negative circa 2008.
4. World population will decline proximate with energy production per capita. “(Duncan, 2005, 10).

In 1893 Henry Adams predicted that electric power would speed up the collapse of the society. A one scenario in The Olduvai Theory predicts that world population will peak at 6,9 billion around the year 2015. After that, population will decline to 2,0 billion in 2050. (Duncan, 2005, 10.)

3.3 Energy Return on Energy Invested – EROEI

EROEI is a term which refers to the ratio of much energy is gained from an energy production process compared to how much energy is used to obtain that energy. For example when finding new oil fields it will take energy to find it and build the necessary tools to harvest it. (Murphy and Hall, 2010, 102.)

EROEI is calculated using the following equation:

$$\text{EROEI} = \frac{\text{Energy gained}}{\text{Energy required getting that energy}}$$

The authors think that EROEI may very well be the future tool when calculating and making decisions between different energy sources and they are amazed that no organization, governmental or non-governmental, has tried to develop and understand this theory any further. For example, they claim that even a modest understanding of EROEI would have saved U.S. taxpayer´s money, in a way that when U.S. decided to invest in corn ethanol, they would have soon realized that not even the highest EROEI was too low to make an impact on national scale as a fuel and terminated the project. (Murphy and Hall, 2010, 114.)

Murphy and Hall both agree that improvements to the theory and data of EROEI have to be made. They suggest the following improvements which are designed in the use of U.S.:

“

2. Most fundamentally, an enormous overhaul of how we undertake and catalogue national assessments of energy used in all aspects of our lives.
3. For example, the quantity and quality of the data on “energy costs of energy generating industries” must be enormously increased. Specifically we need much better data and analyses on:

   • Energy costs of the U.S. oil and gas industry
   • Energy costs of mining and transporting coal
   • Energy used in, e.g., our food system
   • Energy costs and gains of various conservation systems, such as housing insulation

4. Derivations of the energy cost of backup, distribution, and transportation systems and so on for wind turbines, photovoltaic’s, and other intermittent sources need to be calculated so that a more comprehensive and realistic EROI for these important new sources can be derived.
5. Estimates of jobs created per energy invested or generated for any and all of the alternatives.
6. A better understanding of the relation between energy use and economic activity. Most existing economic models have been of little or no help in predicting or helping us adjust to peak oil and subsequent economic

> effects of 2005 – 2008, and the argument of many economists that somehow the market will blindly guide us through all of this is a very dangerous assumption.” (Murphy and Hall, 2010, 115).

Generally, Murphy and Hall state that certain ways should be changed regarding energy consumption:

1. Oil and gas heated houses should think another way of heating. This would free up oil and gas to some other use.
2. Improving transportation systems should not be the key feature of future regional planning. The focus should lie within to provide people homes near where they work.
3. Food should not be wasted. For example in the U.S. ¼ of the food produces is thrown away in the end. This is a huge unnecessary way to waste energy. (Murphy & Hall, 2010, 116.)

4. OIL DEPENDENCY

When you think about how dependant we are on oil, the first thing usually that comes to mind is how transportation will be possible as it is one of the most obvious. Second would probably be heating and electricity. But the truth how dependant we are is much worse that what you can imagine.

Oil is used in almost everything we use in the modern industrial countries. Directly or indirectly. To point out a few that we believe will be the most crucial. If you look around yourself we are sure you will see something either made out of oil or made by oil. If you are reading this thesis from a computer, the screen you are looking at and keyboard you are writing on is made at least partially out of oil. The clothes you are wearing have oil in them and everything else around you is most likely to have been transported or built using oil powered machinery.

Almost all plastics are made mostly out of oil. Plastics are one of the greatest inventions of the industrial age. It is an easily moldable durable and cheap substance that can be used for millions of different applications from medical tools to carpets on the floor. (FAO, 2009.)

4.1 Vicious Circle

At the moment people are basically creating a new market around energy every day. If you think about it every purchase one makes is a purchase of a product as much it is a purchase of a specific amount of energy. For example a purchase of a hamburger is the ultimate end-product which has travelled all the way from cold-chains linked to another, all the way up to the field which was ploughed by a diesel powered tractor.

Energy and business are linked closely to one another – without the other, neither of them cannot exist. But when other grows so does the other. For example the more a business grows the more it needs energy, the more it needs energy, the more energy is produced, the more energy is produced, the more ones business grows and so on. (Roberts, 2006, 163.)

4.2 Turning a Blind Eye

As it is clear that at some point supply of oil will drop and this will cause the rising of prices, it is surprising that no major steps has been taken to be ready for this impact. As the oil crisis of 1973 showed, if no precautions are taken, the fall is inevitable. The longer we wait by doing nothing the more certain will the next oil crisis be and it may not be as delegate as the crisis of 1973, which only reminded us about the risks of conspicuous consumption, but did not require us to change the way of living – it was simply just another political decision. As the next crisis is not necessarily a political one, it might have an everlasting impact to our world. (Roberts, 2006, 333.)

5. ENERGY SOURCES

Alternative resources are often seen as the salvation for oil dependency as technology has developed so dramatically over the last 200 years. The problem that we are facing though is that the even though we have put a lot of money and effort into alternative resources there is still nothing as energy dense, easy to transport and easy to use as oil. The ease to produce oil has also been relatively cheap compared to any large scale comparant energy source.

In any case it is still important to look at the options we have created and study what would be the most realistic option to compensate the decline of traditional oil production. In this chapter we will study the most viable options of alternative energy and focus on the ease of use, how much production could grow and what tradeoffs might it have.

Countries and economies across the world are now trying to figure out what will be the next big breakthrough but still haven’t come to a consensus on what would be the best option.

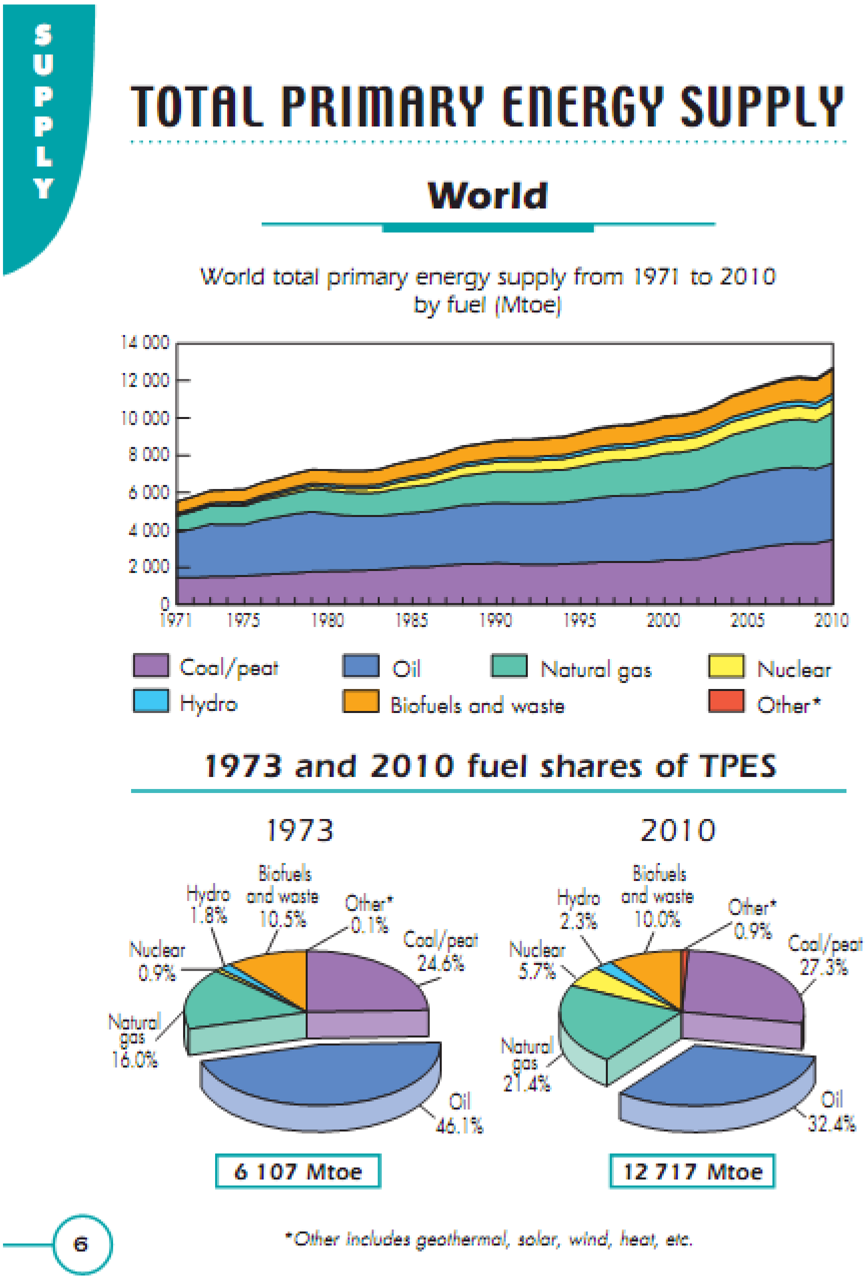


Figure 5. “World total primary energy supply from 1971 to 2010 by fuel (Mtoe)” (IAE, 2012, 6).

5.1 Wind power

Wind power is one of the best alternative resources as it doesn’t have a lot of limits to where it can be produced and it is also environmentally friendly as it cause´s very little damage to the environment around it. It also produces 0 co2 emissions if you do not count production emissions so it is a good option in the fight against “climate change”. Wind power is also a good choice of power in terms of EROEI at a level of 25.2. (Kubiszewski & Cleveland 2007.)

The problem wind power faces is that it still isn’t worth building them. Even though running costs and maintenance is low, the costs of building it are moderate compared to what it produces. Wind turbines lifespan is generally considered to be from 20-30 years. (National Wind, 2012, 1.)

Another problem wind power has is that the energy produced can only be transported through electric grids and batteries so it cannot be considered as a replacement for oil.

5.2 Hydropower

Hydro power is also a very good alternative resource as it is relatively cheap to produce and has a long lifespan. It also produces zero co2 emissions so is also a goof tool for fighting “climate change”.

The problem hydropower faces is the restrictions to where it can be built. As it has to be built in places where water falls down it is very limited where it can be produced. In countries like Finland practically all possible hydro energy places have already been harnessed and it isn’t really a viable option to be considered as a tool to fight an energy crisis.

Even though the hydro plants can also be manmade, it sometimes has devastating effects on the surrounding environment and sociopolitical tension. When dams are made they usually cut off or reduce water supplies downstream. As excess water is also used commonly for irrigation it usually drains out most of the water downstream. This is something also causing problems politically for example in the Middle East as Turkey, Syria and Iraq dispute over water supplies of Tigris.

The EROEI of Hydro power is very site-specific and varies a lot. It has been reported to range from 11.2 to 267:1. Like Wind power hydropower energy transportation is also restricted to the electrical grid and batteries. (The Oil Drum 2008.)

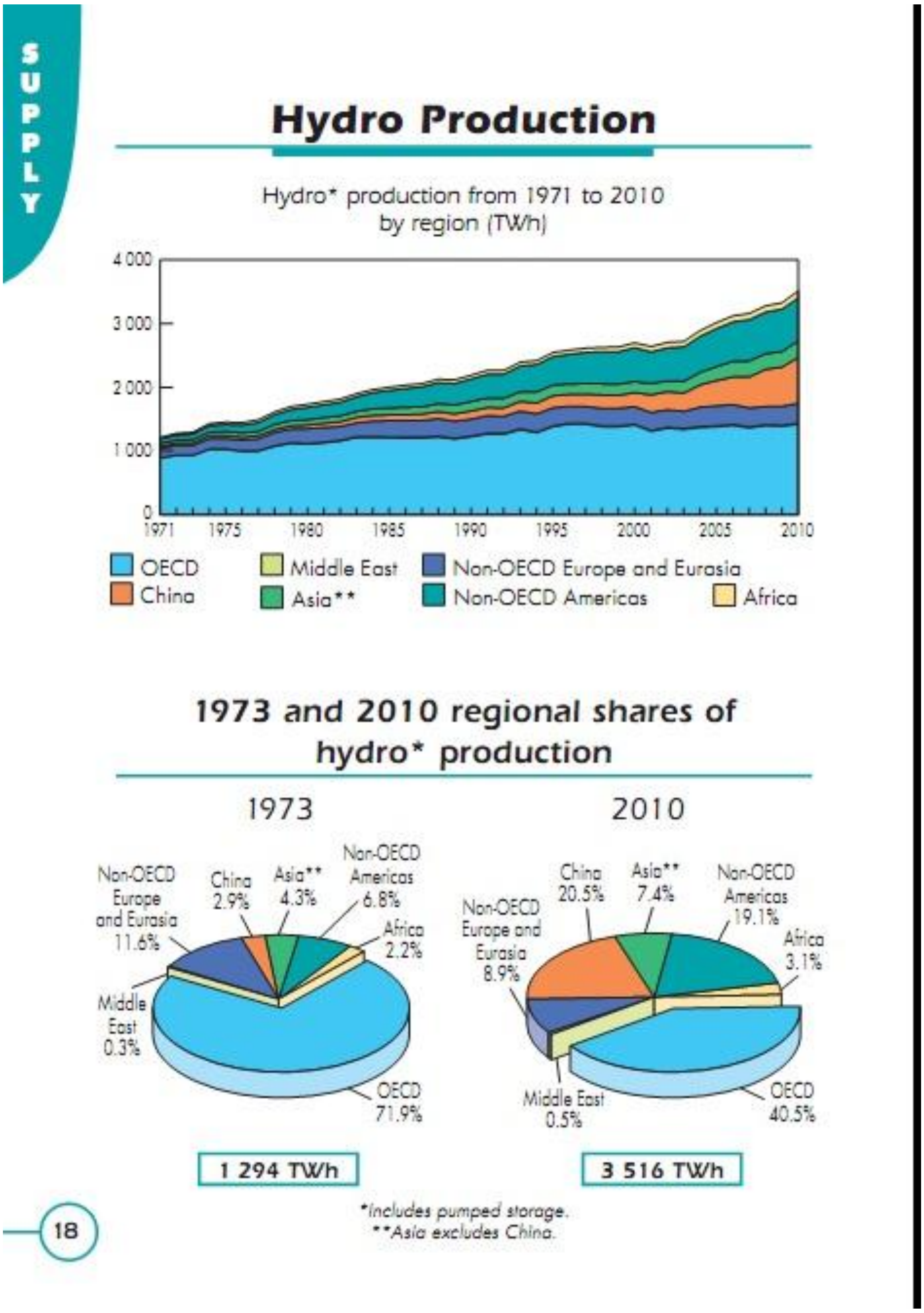


Figure 5.2. “Hydro production from 1971 to 2010 by region (TWh)” (IEA, 2012, 18).

5.3 Solar Power

Photo Voltic (PV) power is also a rapidly growing energy source but still faces a lot of challenges. Even though it is “free energy” as it is from the sun, modern photovoltaic energy requires rare or energy hungry raw materials such as silicon. This is predicted to become a problem if photovoltaic technology would be adopted in large scale as the material costs would raise dramatically.

PV power is also hard to transport and store and large scale usage would mean sharp rises on copper and aluminum which are under pressure of high prices anyway. To cover the diminishing oil production and supply would require enormous capacity. The annual increment of oil and gas is usually greater than all the entire photo voltic energy produced.

The future and importance of PV is hard to predict as it is a rapidly developing technology as efficiency and manufacturing materials are predicted to improve making it a more feasible option.

The EROEI of PV is estimated to be from 3,75:1 to 10:1. (The Oil Drum 2008.)

5.4 Geothermal Energy

Geothermal energy is produced by using the geothermal heat to make electricity or to use the heat itself. The worldwide geothermal direct use capacity that can actually be tapped in around 16000-17000 MWt. At the moment around 9000MWs has been taken into use. Most of today’s geothermal plants exist in places where hydrothermal resources exist.

Geothermal heat pumps which produce heat from usually “warm” shallow soils or its water are becoming more and more popular as it is an economically friendly and stable choice for producing heat for a household. The United States has the largest amount of geothermal pumps at around 600000.

The problem with geothermal energy is that feasible areas where it can be used commercially are very restricted and technology isn’t advanced enough yet. Even if new technology would bring a breakthrough in the industry Geothermal energy will not be able to compensate for oil as it is also not easily transportable and restricted regionally. (The Oil Drum 2008.)

5.5 Natural Gas

At the moment there has been a Gas boom in the world and especially the US. Shale gas has become a significant source and new technology has made it more accessible thus making previously unreachable sources of gas reachable. On the short term it has caused domestic gas prices in the US to plummet and the US is considering starting to export it as producing the gas at the moment cost more than returns. Liquid natural gas “LNG” technology improvements have made gas “easily” transportable. LNG can be put into ships and transported anywhere in the world. This gives natural gas a possibility to reach new places and has shaken off the restraints of gas lines.

Natural gas has been predicted to play a major role as a global energy source. In a global public survey of public policy makers, pension funds, sovereign wealth funds and major private equity and infrastructure funds, 64% of the respondents expected gas to improve its global market position compared to other energy sources. Only 11% expected renewable and 23% expecting today’s energy balance in favor of oil and nuclear power to remain unchanged for the next 10 years. Gas prices in general are less volatile than oil as it has longer-term contracts and less demand elasticity which also make it an attractive investment for investors. (World Pension Fund, 2012, 1-3.)

Gas can also be used in the transportation sector will relatively small adjustments which make it a viable resource to contribute as a possible replacement for oil. The EROEI of Natural gas depends a lot on how it is produces so it is hard to estimate. Estimates range between 5-26:1 in conventional natural gas. (World Nuclear Association 2012.)

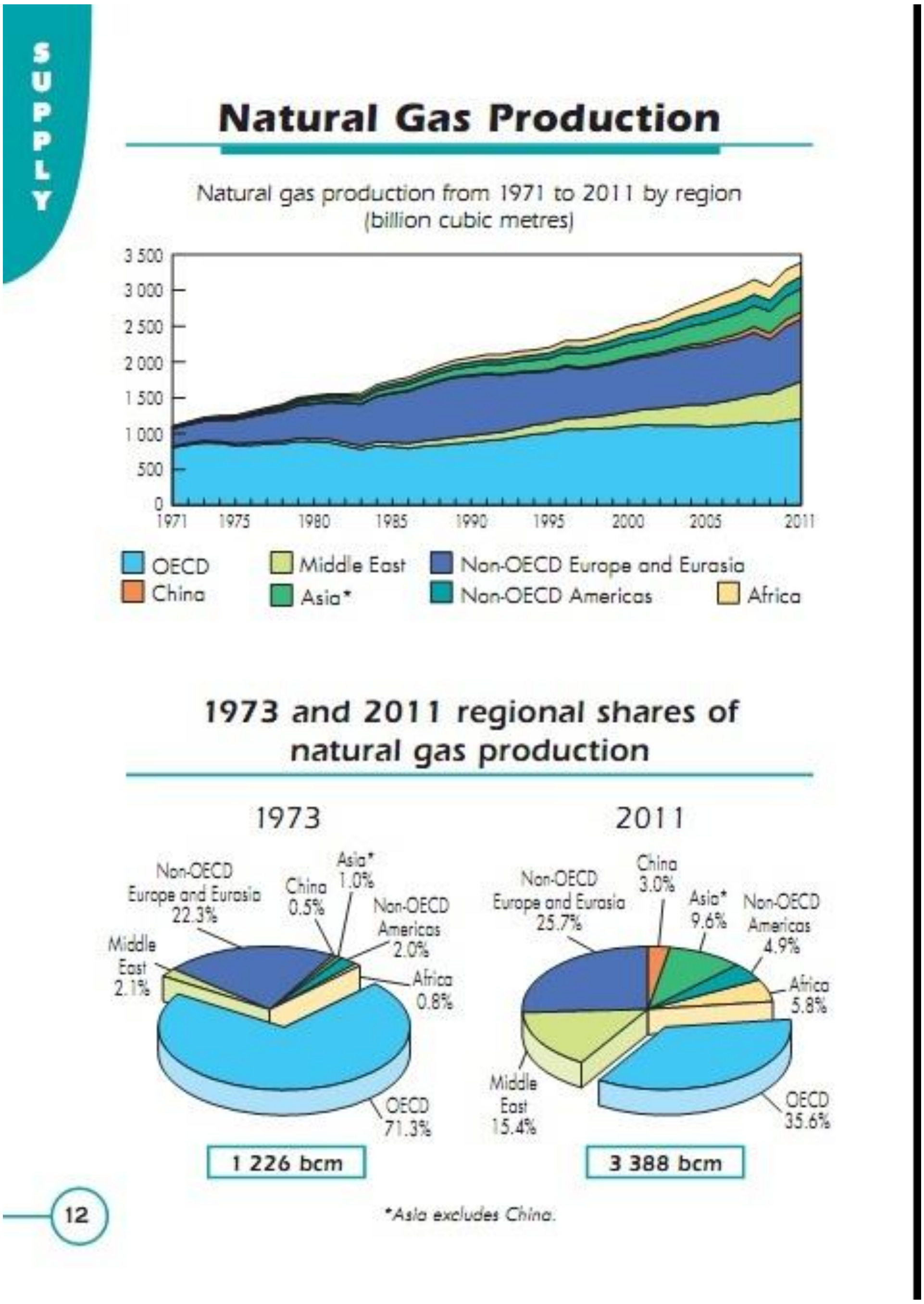


Figure 5.5.. “Natural gas production from 1971 to 2011 by region (billion cubic meters)” (IEA, 2012, 12).

5.6 Nuclear Power

Traditional nuclear power has a strong part as a provider for energy in the world. In 2012 It accounted for 5,7% of the words produced primary energy.

Nuclear power is based on Einstein's theory of the balance of mass and energy which is described with the equation E=mc2. (IEA, 2012, 6.)

Most of nuclear energy is produced with a controlled fission reaction. In a fission reaction the nucleus of an atom splits in to two or more lighter nucleuses and the atom breaks into many lighter atoms of different elements. During this split the atom shoots out neutrons. Part of the atom turns into energy.

Fission reactors uses Uranium is a nonrenewable resource, but according to different sources uranium will last for a long time and the quantities are higher than commonly perceived. Estimates by the (World Nuclear Association 2012) are around 70-90 years. More pessimistic estimates last for 42 years. (European Commission 2001.)

I have to mention looking estimates of uranium online was extremely difficult as there are so many different estimates depending on what reserves are calculate. Known reserve, economically useful reserves or estimated reserves.

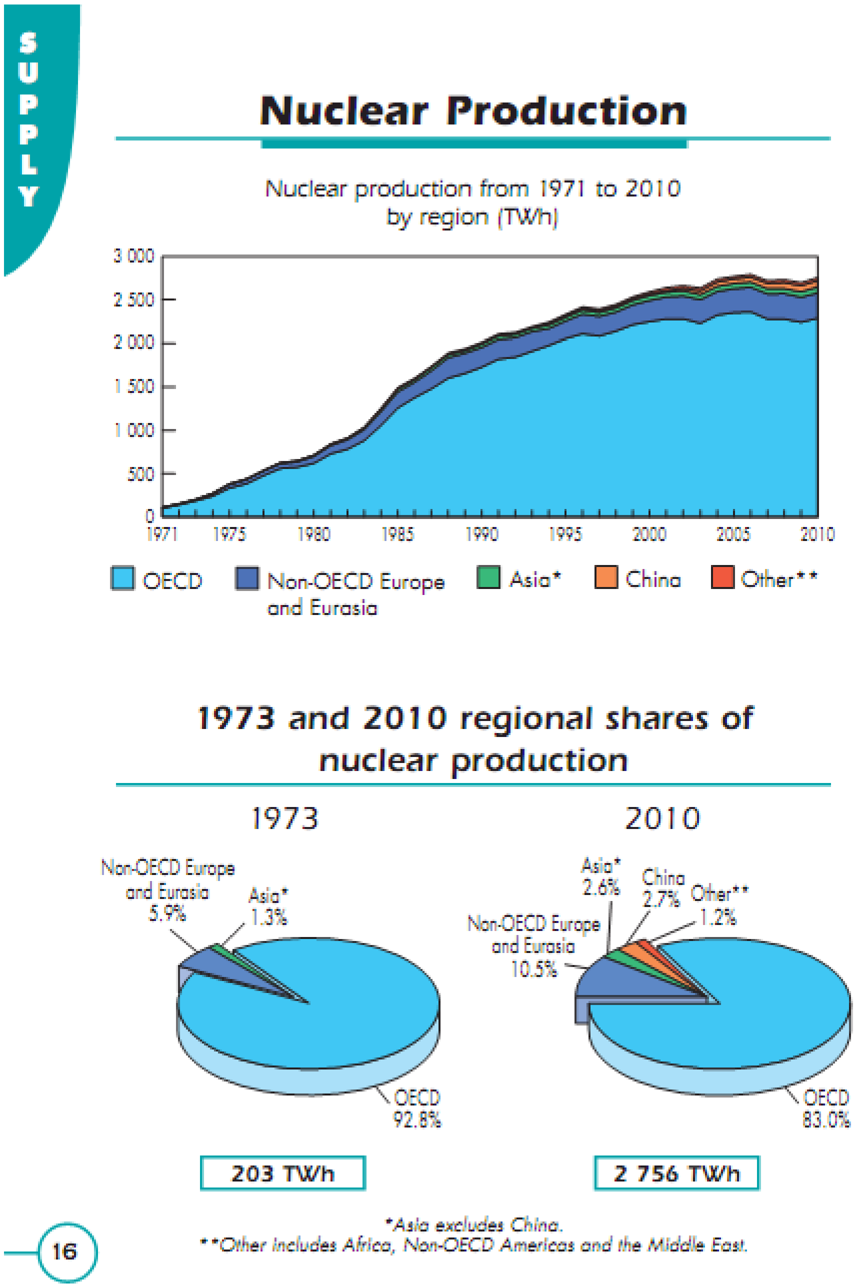


Figure 5.6.. “Nuclear production from 1971 to 2010 by region (TWh)” (IEA, 2012, 16).

5.7 Coal

Coal has been used in a large scale ever since the beginning of the industrial era. Coal is still an abundant resource and at current rate of production is predicted to still last for another 150 years. Coal is still an important source of energy in the world especially in developing countries and the demand is expected to grow in the future. (World Energy Council, 2007, 123-135.)

The problem with coal is that it lets out a lot of co2 when burned and is not a very sustainable source of energy and if demand and production grows as we try to fight the energy needs caused by the scarcity of other sources it will not be a sustainable answer to our problems.

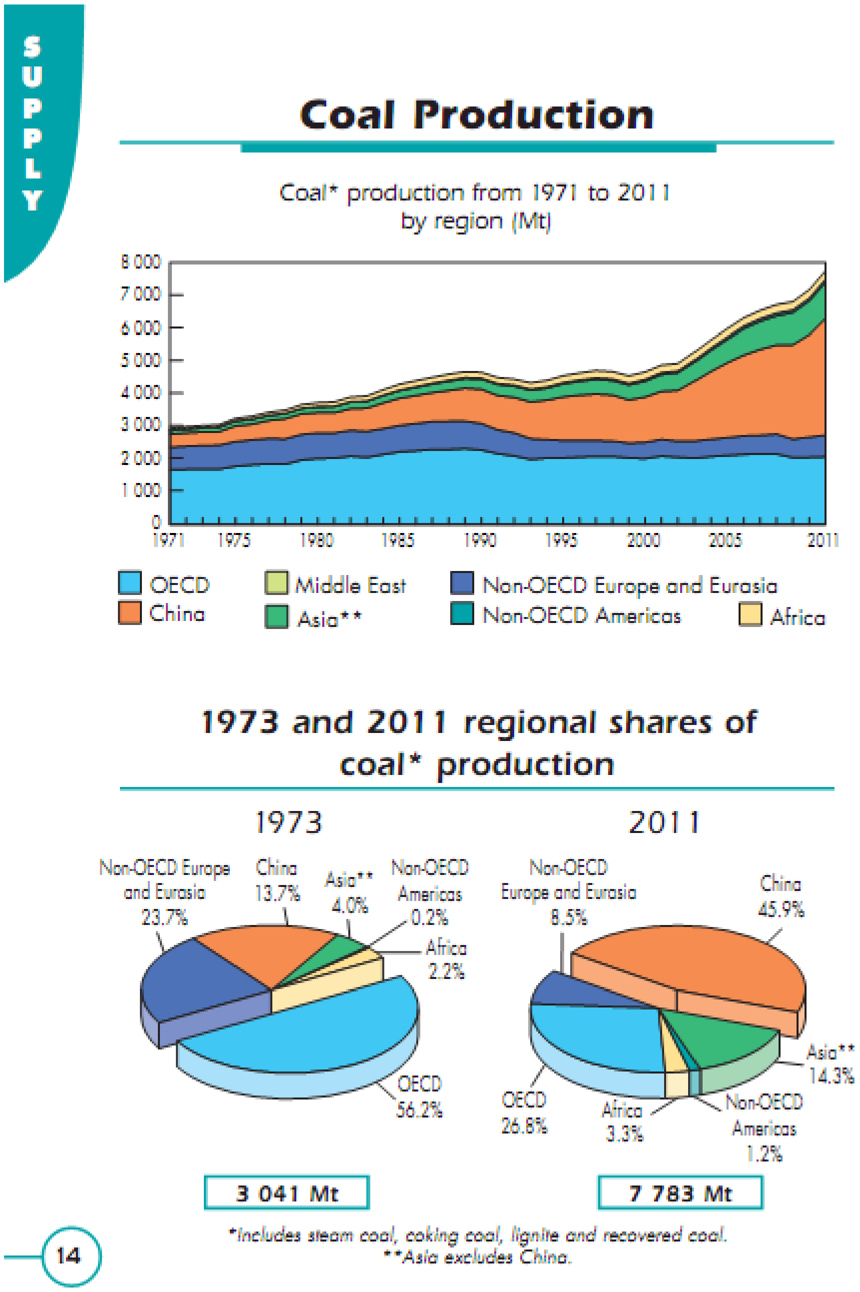


Figure 5.7. “Coal production from 1971 to 2011 by region (Mt)” (IEA, 2012, 14).

5.8 Unconventional oil

Unconventional oil is oil produced by unconventional methods. Conventional oil pumped from oil wells are evidently becoming more scarce as explained earlier which has forced producers to look for new technics and sources of oil extraction. Below are explained a couple of them.

5.8.1 Oil Shale

Oil shale, also known as Kerogen shale is a fined grained sedimentary rock containing kerogen. Usable Oil is produced by heating oil shale to a sufficient temperature which causes the chemical process to yield a vapor. According to the 2010 World energy outlook oil shale reserves are predicted to be around 5 trillion barrels of which around 1 trillion barrels are technically recoverable. To put into scale proven conventional oil reserves are estimated at 1317 trillion barrels. The EROEI of oil shale is hard to calculate as there are many different kind of methods to extract the shale oil. According to the IEA estimates range from 2-5:1. (IEA, 2010, 165-169.)

Availability and price of petroleum determines the viability of a large scale oil shale industry. At the moment with oil price still relatively low, there are few if any economically viable deposits. Nevertheless some countries without their own oil reserves decide to invest in oil shale production as oil prices are predicted to rise in the future.

5.8.2 Oil Sands

Oil sands otherwise described as natural bitumen and extra heavy oil are abundant and have vast quantities of reserves. Despite being expensive and having technical challenges it has aroused interest of companies to start exploring and exploiting as the price of oil rises.

Natural bitumen reserves have been reported in 598 deposits in 23 countries. In 2006 Canada was the only country to produce commercial petroleum from oil sands. Canada Averaged 1.25 million barrels per day in 2006. (World Energy Council, 2010, 123-135.)

Oil sand extraction has aroused criticism by activist groups such as Green Peace and Climate Reality Project. Oil Sands can affect the land when the bitumen is initially mined. Water is required in large quantities during the separation process of the oil and sand which also limits production to areas with water shortages. Heavy metals are naturally in the oil sands and may be concentrated in the extraction process. (Wikipedia 2012.)

As an addition to cover loss in oil production oil sand will have value as the large amount of reserves and high expense naturally and technically means it will be unlikely to ever be produced in a very large scale, but will be a resource we will be able to reach oil in the future.

5.9 Biofuels

Biofuel is an alcohol made from vegetable oil or animal fat. Biofuels are usually used as an additive to diesel to make biodiesel which is said to be less environmentally harmful produces less co2 emissions than conventional diesel or fuels. This is why many nations around the world went into a hype and started subsidizing biofuel production and legislated higher amounts of ethanol into biofuel. However biofuels also rise up a lot of debate.

According to the European environmental Agency biofuels do not address the global warming concerns as burning biomass increases the amount of carbon dioxide in the air. It is widely assumed that biomass or biofuels is carbon neutral as it has collected the energy and carbon it needs to grow during its lifetime. What is usually forgotten is that the land itself when producing biofuels cannot produce plant life or feedstock so there is a loss in carbon binding organisms. There is also the question of land deterioration and the pollution caused when harvesting manufacturing and transporting the fuel. Unless legislation is enforced in how and where bioenergy is produced it might result in an increase of co2 and pollution in the air.

Another arguable statement is that when biofuels are made out of feedstock it uses the food desperately needed to keep up with the exponential growth of human population. Second generation biofuel which are produced from sustainable feed stocks give more hope on this side but the EROEI for these fuels is even lower than energy low biofuel in general. Based on the assumption that biomass is carbon neutral several reports suggest that bioenergy could or should provide for 20% to 50% of the world's energy needs in the coming decades. Doing so would require doubling or tripling the amount of plant material currently harvested in the world. Witch you could say is unlikely or impossible. (EEA, 2011, 1.)

There are positive aspects to biofuels as well. Even though the EROEI is only between 1-2 at the best, it is still a liquid fuel so it is easy to transport, easy to use, possible to produce practically anywhere and energy dense when ready. Even though the tradeoffs of using biofuels is high it still has important role in helping the fight against oil depletion and is a viable option that nations will want to hold onto. (Peakoil.com 2010.)

6. THE EFFECT OF THE OIL CRUNCH IN FINLAND

The share of Oil in Finland's total energy consumption is about 25%. Most of the oil consumption is used in transportation. Oil is also used for heating in ¼ of residential and service buildings and is a significant source of energy in the agriculture and forest industry.

The Import of oil in Finland was 2010 11,2 million tons. Combined homeland sales where 8,9 million tons. The quantity includes bitumen, lubricants and raw materials for the petrochemical industry.

Petrol was sold 2% less than the previous year, but diesel was sold 8% more. The consumption of petrol has been going down for a longer time. The development of passenger car technology has improved their efficiency and a larger portion of passenger cars are diesel powered. The significant users of diesel are in business transportation.

Under half of fuel oil was used in heating and the rest in agricultural and forest industry machinery and equipment, construction and manufacturing. The weather in Finland is a significant variable in the consumption of fuel oil used for heating. In the year 2010 light fuel oil consumption was 6% more than the year before. Sales of heavy crude oil grew by 13%.

In the year 2010, 94% of crude oil was imported from Russia and 5% from Norway. Additionally crude oil was imported from Denmark, Kazakhstan and from Great Britain. The high amount of Oil imports from Russia is because Finnish refineries are able to utilize Russian high sulfur crude oil, contrary to many other refineries. Finland has two refineries, one in Porvoo and another in Naantali

The imports of crude oil in 2010, according to foreign commerce statistics where 5,2 billion Euros. (Öljyalan Keskusliitto ry 2012.)

6.1 Consequences of peak oil in Finland

Saving energy is something most people are taught since they are children and there is a good and important reason for it. People in my generation born after the 80`s have never had to conserve energy for any other reason than their own conscience or to save a bit of money. We have been living in an environment of energy abundance.

Some people in Finland have experiences of oil crisis from the 1973 crisis. This crisis was caused by Egypt’s and Syria’s war with Israel and the decision of the OPEC countries to limit oil export to countries that support Israel. The consequences were worldwide and effected in many ways.

For Finland the situation was eased by getting more oil from the former Soviet Union. In December 1973 the Government was forced to publish a broad energy saving program. The program include for example: Speed limits were caped to 80km/h, advertisement light had to be turned off at night, room temperatures were lowered to 20 degrees Celsius and heating cars was limited. Housings additional heating, highways lighting, private aviation and motor racing was forbidden entirely. There was also discussion of forbidding TV on Monday evenings. The government hoped that Finnish citizens would obey these instructions voluntarily so that it wouldn't have to depend on force. (Yle, Elävä arkisto 2012)

The possible upcoming oil crisis might have similar effects as what Finland experienced in 1973. Limitations will be sanctioned and inflation will skyrocket. The biggest difference as we have earlier discussed is that the next crises isn't solemnly a political dispute, but a permanent problem we will have to tackle.

6.1.1 Financial

Finland in 1973, as mentioned, had to implement several restrictions on its citizens concerning energy consumption. At the end of year 1973 oil cost four times more than on September the same year. This resulted as restrictions on energy consumption and as in high inflation. (Yle, Elävä arkisto 2012.)

Inflation was above 15% in 1973 and in 1974 (Tilastokeskus 2012). One reason to this was the oil crisis of 1973 as Arab members of the Organization of Petroleum Exporting Countries (OPEC) announced an embargo against the United States in response to the U.S. decision to re-supply the Israeli military during the war. OPEC members also extended the embargo to other countries that supported Israel. The embargo both banned petroleum exports to the targeted nations and introduced cuts in oil production. The price of oil per barrel quickly quadrupled and led to the rising of consumer prices worldwide, including Finland. (Office of the Historian 2012.)

In the 1970´s it was possible for Finnish government to respond quickly to this threat by using macroeconomic tools by implementing different fiscal and monetary policies. Although these new policies were quickly made they did not take effect until 1978. (Tilastokeskus 2012.)

6.1.2 Stagflation

The financial term explaining the financial situation the world would face is stagflation. The definition of stagflation is: "A condition of slow economic growth and relatively high unemployment – a time of stagnation – accompanied by a rise in prices, or inflation”

“ Stagflation occurs when the economy isn`t growing, but prices are, which is not a good situation for a country to be in. This happened to a great extent during the 1970`s, when the world oil prices rose dramatically, fuelling sharp inflation in developed countries. For those countries, including the U.S., stagnation increased the inflationary effects.” (Investopedia 2012.)

The best way for governments to battle stagflation would be for it to drastically lower rates, but as the rates are already at historically low levels. This will not be possible. In the 1970`s oil crises the situation was only temporary, but as we are at the peak right now will enter a long struggle.

At the moment we are seeing strong signs of this, as entities such as the European Central Bank and the FED have promised unlimited money supply to the markets. Announcements of unlimited money supply are good for financial speculators, but many financial professionals have started to question is it good for the rest of us.

6.1.3 How will the banking system be effected

There are three main types of money. Commodity money, fiat money and bank money. Commodity money is based on the value of a commodity such as physical gold. Gold will always keep its value as it is a physical object and is commonly recognized all over the world at an almost similar price. Fiat money is government issued money, which the government has decided to be accepted as legal tender. In other words the money itself has no value unless people believe it does. Bank money is money that has never existed except in bank accounts and bank transfers. (Cliffnotes 2012.)

As the most modern banking systems depend on growth to keep going governments try to keep money available and moving. The problem they are facing now, is that as prices of practically all commodities are rising at very fast rates and they can’t keep up with the inflation. The more they “print” money the more the prices rise. The question is; when will people lose faith in their currency and how will the banking system and governments adapt?(Talous Sanomat, 2012.)

6.1.4 Political

In case of a sudden oil crunch and suddenly risen oil prices could be devastating for the government parties of that time. Since “politicians are seldom inclined to deal with problems proactively, and will be unlikely to act decisively until crisis has arrived full-blown” (Heinberg, 2003, 204). A major oil crisis could effectively compromise the governing government as opposition parties could start accusations why the government did not take the necessary precautions to avoid this crisis or at least to lessen the impacts of a sudden crisis.

In the end, it is extremely hard to predict how and what would be the political consequences of an oil crunch in Finland.

6.1.5 Transportation

How a hard a sudden oil crisis would effect to, for example, private motoring in Finland would effectively depend, for example, on the timing of the crisis. If it were to happen in the next five years compared in, for example, the next twenty years is a huge deal. As over a short term, more energy efficient cars will be built but in the long term a fewer cars will be built and at some point only the rich can afford to buy them. (Heinberg, 2003, 191.)

So eventually, if Heinberg is right, the oil crunch would not affect private motoring that much if it were to happen, let us say, in the year 2050 as private motoring would have decreased already from its current state.

Anyway if the oil crunch were to happen in the near future the impacts could change transportation for once and all. Speed limits could be lowered as driving in slower speeds save fuel and other restrictions could be set as well. Government could try to divert fuel from the private motoring to public transportation and for the use of actors such as the military and energy companies.

Flying to holiday destinations could become a luxury for only a few and chosen. Depending on the severity of a possible crisis flying could also become entirely impossible for the public as fuel could be redirected by the government as mentioned in the last paragraph.

Public would also see the effect of reduced transportation in disruptions in the distribution of goods. Some items could become obsolete as the globalization has driven manufactures to the countries where production is cheap. The shipping of these products could become impossible or at least more expensive. This would show as empty shelves or in increased prices. In the end the scarcity of fuel would lead to “reversed globalization” and the start of local production once again. (Heinberg, 2003, 193.)

6.1.6 Food and agriculture

Throughout the 20th century food production has grown hugely a country after country. This is heavily linked either directly or indirectly to energy inputs. As stated before transportation of products, as well as food, from distant countries would become more expensive or non-existent in case of an oil crunch. This would mean that food products would become more one-sided at least at first until domestic farming would yet again be more profitable or profitable at all. (Heinberg, 2003, 193.)

Through it is true that some of the food shortage could be compensated with new domestic production the lack of oil and fuel or the expensiveness of these would lead at least to risen food prices or partially empty shelves. The positive side of an oil crunch would of course be that domestic production would increase and possibly more jobs would be created. It still has to be kept in mind that the living standard would still decrease in spite of the risen domestic production and the scarcity of food could lead to diseases and wars – eventually population would start to decline if the crisis would be extremely severe. (Heinberg, 2003, 194.)

7. ENERGY PRODUCTION AND CONSUMPTION IN THE FINLAND

Finland has a cold climate and there are long distances to travel, the industrial industries are fairly energy intensive, which is why Finland consumes a lot of energy. Finland uses a lot of energy which is why energy strategies and energy security is crucial for the well being of Finnish citizens.

Finland's self sufficiency in energy production is around 30%. It is based on hydropower, peat and biofuels like black liquor and wood. The rest 70% is based on imports. Approximately 80% of imported energy is from Russia: Oil, coal, gas, electricity and uranium. (Öljyalan Keskusliitto ry 2011.)

According to Statistics Finland; in 2010 Finland used 1,46 million Tj which was 10% more than in 2009. 8% more electricity was used than in the previous year, totaling 87,7 TWh. The increase of renewable energy increased by 16% and fossil fuels increased by 11%.

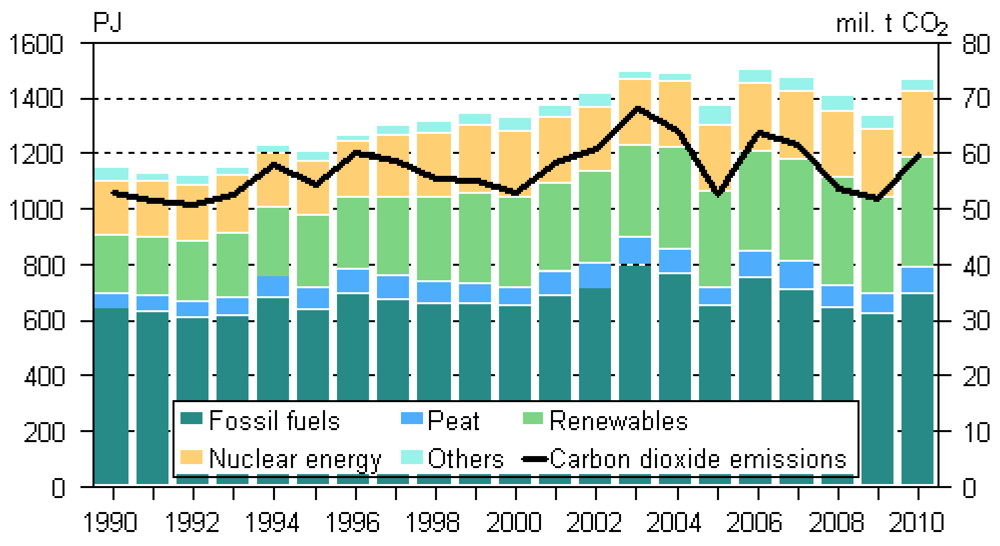


Figure 7. "Total energy consumption and carbon dioxide emissions in Finland" (Tilastokeskus, 2010).

The recovery of industrial output increased energy output in 2010. Most growth was caused by the recovery of energy intensive industries. E.g. Forrest-, paper- and Chemical industry.

	2009	2010	Change %
Oil	335 495	353 295	5
Wood fuels	269 261	319 663	19
Nuclear energy	246 555	238 789	-3
Coal	151 267	188 500	25
Natural gas	134 568	148 680	10
Peat	71 978	94 545	31
Hydro power	45 263	45 875	1
Net imports of energy	43 504	37 802	-13
Wind power	996	1 060	6
Others	32 441	35 639	10
Total	**1 331 328**	**1 463 846**	**10**

Figure 7. “Total energy consumption 2009-2010, Terajoule” (Tilastokeskus 2010).

7.1 Renewable Energy in Finland

The share of renewable energy consumption out of total energy used in 2010 Finland was 26% Finland’s EU targets for use of renewable resources is 38 % by the year 2020. (Tilastokeskus 2010.)

Finland is one of the world`s leading countries in renewable sources of energy, especially bioenergy. Most important source for the country is wood and wood-based fuels in particular and also hydro-, wind-, ground heat and solar energy.

The objective of the national energy and climate strategy is to increase the use of renewable energy and spread out the mix of energy sources. This is also a part of Finland`s climate target as renewable resources do not increase carbon dioxide emissions. The strategy also supports Finland's technology exports for the industry and has already become an important part of Finnish exports.

In Finland peat is classified as slowly renewable. It is an important source of energy at 6% and holds a significant position of Finland's energy balance. As a domestic fuel it also creates lots of jobs and creates security as a local energy source. As Finland is still heavily dependent on foreign energy it is important for it to make some fuel themselves. (Työ- ja elinkeinoministeriö 2011.)

7.2 Fossil fuels in Finland

About 80% of fossil fuels in Finland where imported from Russia. Finland is very dependent on Russia in its energy needs and changes in this cant been seen in the close future as Finland does not have practically any commercially usable fossil fuel resources.

25% of Finland's fossil fuel consumption was fueled by oil. Oil was used to produce electricity only around 1-2% and was used primarily in backup power plants. Gas is the second most important fossil fuel as a source of energy. Gas accounts for about 11% of primary energy production in Finland and around 8-10% of electricity.

Coal accounts for about 10% of primary energy and 17% of electricity production. Peat accounts for 7% of primary energy and about 8% of electricity production. This means coal and peat together covers a significant part of Finland's electricity production (24%). In other places in the world coal is usually the most important source of energy for electricity production.(Energianet – 2012)

8. EXPERT INTERVIEW

8.1 Expert Interview from Ministry of Employment and the Economy

We held an interview in Finnish at the Ministry of Employment and the Economy in Helsinki on the 23th of November. The expert we interviewed wished to stay anonymous. The audio of the interview was recorded and the following text was approved by the ministry.

Question 1

What is your opinion about peak oil? Has it happened yet?

Answer 1:

It is true that in certain oil production areas it is impossible to recover any more oil with the technology they are using, but for example in North Sea they have succeeded improving oil recovery rate with new technology. For example previous estimations about oil reserves in certain areas have been corrected because of this technology. Now with this new technology the life span of old oil deposits have increased.

It is also true that today new oil fields might be in places where there is no easy access and oil companies want a better price from oil when drilling these areas. If we look the timeline of oil production we can say that there has been a steady increase in oil production. Of course there is been a few dips in that graph but they all have an explanation for example a political one.

There are also different types of crude oil and for example Neste Oil has the possibility to make diesel out of bio components so that this fuel would not contain a single drop of crude oil.

Comments

Our expert mentioned that oil production still has steadily grown as new technologies have been adapted to improve drilling technologies, but he agrees that in some places oil production has stopped and companies have to search for it in harder and more expensive to exploit.

This is in line with Figure 2.2 World oil production where a steady increase in oil production is visible.

Q2: Do you think that if oil reserves would be coming to an end that it is possible to replace traditional oil with alternative means? Do you think that Finland´s position is secure in today´s oil markets?

A2: Firstly I see that the market price of oil tells us where the supply and demand is. For example if oil price would be to increase, new oil drilling sites could be opened (and increase the supply of oil). And of course for consumers it is sad that price increases but in this scenario it is wise to save (and decrease the demand of oil).

What it comes to Finland and oil we cannot expect that everything goes well forever. Finnish government is planning an energy strategy where one goal is to decrease the Finland´s dependency on imported oil. This means that where it is possible we would use another energy resource than oil.

Comments

Our expert from the explains that the price of oil tells us the supply of oil as new areas to drill are opened as the price goes up. He also reminds us that Finland is trying to cut there oil dependency as the government which is in line with targets set by the government mentioned in chapter 7.

Q3: The share of oil in energy production in Finland has dropped steadily for the last 30 years. Do you think that this trend will continue fast enough or should we do something more?

A3: Politics and taxing has played a part in this progression but ideally it would be great that no subsidies would be used. One way to continue this trend would be by adjusting taxes.

Q4: If we were to look 50 years from now and think about oil should the government already plan future changes in Finnish infrastructure for example transportation?

A4: As a member of the European Union we are a part of a plan which is in effect all the way to 2050. The previous plan was for the year 2020 or 2030. So we are currently doing work for the future with the information we have today.

When thinking how we will organize the energy intake on national level we need investments. We however have to remember that after a political decision it takes certain time until we see the effects of that decision in practice. In this decision making future energy needs have to be carefully calculated as these solutions might see the daylight after many years of planning and construction.

Comments

Our expert agrees that it takes some time to plan the enrgy supply and reminds us that Finland is planning for the next 40 years as a part of the EU energy plan. He didn’t answer what these plans could be but he mentiones that we are planning ahead with information we have today which we interprate that there is no drastic changes coming.

Q5: Personally I think that one way for Finland to decrease its energy dependency is to invest in nuclear energy. Do you think that nuclear energy is the better option amongst the other energy sources or just another option?

A5: My response is that it is an option amongst the rest. Finland is a country with cold winters and long distances. Our natural energy resources for example are wood, peat and hydro energy and generally people like to travel and warm their houses. This in mind no energy resource should be ignored.

Comments

The expert agrees that the energy need for Finland is high as it is a cold country and we need energy for heating but doesn’t put one energy source infront of another but instead mentions that all energy sources are to be looked through. He also mentions finland local energy sources as a option to look into. This is in line with what we studied in chapter 7. There we studied the current trends of energy production.

Q6: In which different alternative energy sources should Finland look into in future?

A6: Every option should be researched and then we will see what options work and are the best for Finland.

Comments

It seems there is no certain or obvious choise for Finland which is why further research is needed.This in a way is a shame as it means there is no clear direction yet.

Q7: What do you think would be the best way to organize commercial and public transportation in Finland for the next 10 years? Should we do something in terms of regional planning?

A7: The house prices at the center or large cities are relatively high which is one of the reasons that some people are living quite far from their work places. When thinking individuals the reasons which effect where they live are, for example, location of their work place, location of schools and how big of a house they need.

What comes to regional planning, for example, in the Soviet Union government ordered where to live and where to work. Thinking that would Finnish people agree to that kind of arrangement? In the end if people are given a choice most of them will live as comfortable as possible.

Comments

Our expert gave the impression than regional palnning is not an welcome thing as people like comfort and freedom of choise. There is two sides to this coin as planning takes away freedom of choise but improves the wellbeing of the future and freedom of choise bring comfort but might cause problems in the future if we need to change the system.

Q8: Should the government inform the public in advance of a possible energy crisis?

A8: I believe that the National Climate and Energy Strategy and the ministry preparing and implementing it will discuss all the possibilities and aspects of this case. I am not part of this group but public discussion about this topic is being held between the different political parties in Finland.

Personally I do not believe that the society should command the public how to function. Of course people can save energy by changing their behavior. For example if the petrol price goes up people tend to think how much they are driving.

Currently in Finland there is a company called Motiva Ltd which gives people guidelines in terms of energy consumption and consumption generally.

I do not believe that there is a reason to create panic concerning a possible energy crisis. If that crisis is to come we will deal with it when it comes. At the current situation where the economy is not going too well it is important to let the public live a life without fear.

Comments

The experts opinion is that it is better not to cause panic as we are economically struggling anyway. and there are companies and task forces tackling the issue.

8.2 Expert Interview – Pekka Pirilä

Pekka Pirilä is a retired former Professor of Energy Economics at Helsinki University of Technology. His specialties include Energy economics and energy systems analysis, in particular: Energy system models, energy and climate policy, electricity markets, risk management of energy companies, investment analysis, and energy sector development projects. This interview was held on the 23th of November. The audio of the interview was recorded and the following text was approved by Pirilä.

Question 1

Who are you and what is your professional background?

Answer 1

I graduated from the University of Technology in physics, but started working in the energy field in 1980 for the Technical research Center in Finland and did research there for 20 years. After that I worked for the Aalto University school of Science and Technology for 10 years as a professor.

My own field was the energy economy which I specialized in, but I also worked closely with people in the technical side of energy. The oil dependency we are going to discuss is closely related and a big part of the entire energy economy and is important to understand.

Q2: What is your opinion, have we already seen the peak of oil production or do you believe we will find other or new sources with what we can keep up production growth?

A2: It is possible that we have passed the peak of good quality crude oil production. We have seen a peak after it has leveled but it is hard to predict if we will reach the same level again or not. It has more to do with are we ready to invest more in large scale production for some time frame. It probably could be possible to reach new record levels, but would it be sensible is hard to say.

Especially if we consider other sources than traditional high quality oil, for example oil sands and shale oil. If we count these unconventional sources we will likely reach high levels, but will we reach the same kind of growth we have had before is another question. My personal opinion is that we will have slight growth in oil production for some time to come.

Comments

Pekka agrees that peak oil in conventional crude oil might well have passed. He reminds that unconventional oil still can play a big part in supply and predicts slight growth in production in the future. He doesn’t believe we will ever reach same levels of growth in the future as we have seen before. This is in line with M.K. Hubberts theory as his calculations where made using conventional oil.

Q3: What is your opinion on the Olduvai Theory?

A3: We have had a time of high growth before the 1970`s which made a turn because of political and supply issues. After this it has started to grow again at an less steep level, because of developing countries and especially China`s growth. The theory of the hole society coming down is probably an partly intentional exaggeration, but it is a fact that resources are finite and we won`t always receive good news on this side. The future will not be the same as what it has been until now, but it will be something else.

I wouldn’t agree that the human population will that dramatically fall as requested in the theory. There have been many Oil Theories that have been presented in the past with also early peak levels. I have liked to use in my own presentations the study done about 10 years ago by American Geologists with rational predictions which has also been updated a couple of times afterwards. What I have followed myself especially predictions of oil have not significantly changed.

The biggest changes that have happened are how efficiently we are able to use the known reserves. Before it use to be around 30% and these days it has gone up to about 40% and most likely in the future it is still going to rise maybe up to 50%. The remaining 50% is unlikely to ever be reached. Calculated with these figures peak oil would occur around 2030.

These calculations do not include unconventional oil like oil sand and shale oil which have a lot of known and unknown reserves.

Comments

Pekka predicts that we will be able to improve efficiency to some extent, but it always gets harder to improve and at some point there is a limit. Pekka does not agree with the Olduvai theory in the sence that the human population will fall so dramatically but agrees that we wont always hear good new from this side. Pekkas estimate is that peak oil might happen around 2030

Q4: As the Economy is driven by energy, do you see that our financial system will have to change when production turns to a decent?

A4: There have been problems in the past. During the 1970`s oil crises which happened in two stages. First political crisis that was linked to the war and then there was limitations set by the OPEC countries a couple of years later. During those times the price of oil went up very quickly there was a lot of pessimism in the air and it was discussed than can we keep on producing oil anywhere. But as the prices went up there was a sudden growth in oil production as nations and companies looked for new sources of oil like the north sea and other places where it hadn`t been profitable to produce before.

Comments

Pekka reminded us what happened in the past when there last was an oil shock but doesn’t address the issue we wanted to address which is can the fractional banking system survive a declining economy without growth in the long term.

Q5: Could you say that the 1970`s oil crises was driven by political reasons but the next crises would be caused be limited resources.

A5: It wasn’t only political then, it was also partly to do with that until the 1970`s the price of oil had been going down for a long time and it was so cheap that it was only profitable to produce it in the very cheapest places and there were not motives to invest other places anymore which caused all the focus of oil production to focus on the cheap countries. What this caused was that after the initial shock it took about 6 years for the new investments into oil production elsewhere to start producing.

Lately the international energy outlook reports have been good compared to before, when you had to always read from between the lines as they were driving interests. These days during the current president Birol it is much more objective, open and clear. During the last years they have brought up the issue that getting new investments is the bottleneck to utilizing new oil reserves as they require a large capital. The question it arises is that gathering the capital can be hard and is it worth trying to exploit all the reserves as we have finite reserves. Finding the balance between these is the key. For the next twenty or so years it is more about how much we are ready to invest to grow production and supply, but after that we might face the situation that can`t produce any more however much we invest in it.

Comments

In this answer Pekka Pirilä mentions that investments into new oilfields took about 6 years to yield results. As finding and producing oil needs ever more and higher investments it is likely that when the next oil shock happens it will take even longer for new investments to yield results. This is in line with Richard

Heinberg`s comments discussed in chapter 2 Peak oil: By the time a large scale crisis happen it will be too late to start changing the energy system.

Q6: Do you see that the EROEI of production will become an issue as the level of energy invested in producing something raises?

A6: I have got the picture that people who discuss about EROEI might over emphasize the importance of it. I cannot say I have studied it a lot of this subject, but the picture I have got is that especially on the peak oil websites where a groups of people, who do devote a lot on the subject, discuss about EROEI and the significance of the rise on energy invested, but for me it reminds me of studies previously made on wind power, where it was counted the they would never produce the energy back that was put into them, but when you look at them now, It only takes about half a year for them to produce the energy invested. There are always some way to tune up the calculations to make them look like it is not worth doing. But if we look at it from another direction and consider them as a singular project they usually turn out much better than believed. For example the Canadian Oil sands will most likely bring the energy back much higher than what is put into it. But eventually the limits will be faced and in financial terms there are always limits to profitability and energy is a significant factor and expense in production.

One area where it can be possible for energy invested not to match energy output is biofuels as productions are subsidized and without the subsidies it wouldn't be worth doing.

Also when we think about the costs involved it also has to be accounted that the price of energy is most likely to go up in the future and have to be involved in accounting. It is of course a part of the planning.

Comments

Pekka Pirilä`s answer streangthens what we noteiced while looking for information about EROEI. Finding information about EROEI was very hard and there was no clear line what is the right method of calculating it. There was only rough estimations and discussions but no information about it on credible site`s.

Q7: Could you answer briefly what you think about these alternative energy sources?

A7:

1. Wind power

Wind power these days is at the best is a good and moderate in cost especially in favorable places. But on the other hand it can change a lot on the place where it is. In smaller scale wind power is a good option but if it is put in use in large scale the variability, maintenance and life span will become a problem. At around 10% average of total energy production wind power still works pretty well, but if it starts going up to 20-30% average there will run into new problems.

2. Hydro Power

The issue with hydropower is that it has been practically all been put into use in industrial countries and the possible places we have left raises the question that is it worth ruining the natures value to make power. As a part of the electrical system it is a very good and important part.

3. Photo Voltic

Photo Voltic is coming through strongly globally. When you go to places where the peak of electricity consumption is because of air conditioning it is a very good option. The problem with Photo Voltic is the uncontrollable variables like weather changes and also the predictable changes like seasonal changes.

For Finland photo voltic energy is has value close to 0 as when we need it the most it doesn’t produce anything and when we don’t need power, then it produces it. Compared to countries like Spain who could gain a lot from solar power.

4. Geothermal Energy

Geothermal power can only be produced in very limited places which it doesn’t have a lot of new value in a global scale and most likely won`t change in the future. Another thing entirely is Geothermal heating which is more making energy use more efficient, than producing energy. This suits countries like Finland very well where we can use geothermal heat to even the temperature.

5. Biofuels

At the moment they are mostly grain and sugarcane based and then there is also palm oil produced oil which is used with diesel. The problem with biofuels is that it uses the same land as what could be used for food production. The question is not are we using food to produce the oil, but are we using the land for something else which you could produce food.

Biofuels produced from residue or organic material which doesn’t compete with the land use of food production is another question. Technologies are being developed in Finland where they use other organic material or residues to produce biofuels. Previously these materials have been used to make electricity or process heat.

All of this has got to do with how the human population growth will continue in the future. According to reports of the UN for example the human population growth should slow down and stop through development. For example in China the Mao`s one child policy has slowed the growth and will most likely start decreasing in the future.

If this does happen development can go forward in the future. If population growth doesn’t stop then we inevitably will hit a point where it has to happen. If we want to improve our standard of living, the limited resources will eventually draw our boundaries.

6. Gas

Natural Gas in general mostly follows the same production curves as oil and is produced in the same areas. Natural gas has surprised in the last couple of years because there was a common thought that the unconventional reserves would not be able to be used but recent development has proven that they can be used and has started a boom especially in United States. There are two types of natural gas that provide for most of the United States Gas. One is called cold bed methane and the other is shale gas and there growth potential in the future is high. What the boom created was an abundance of gas reserves and production which then brought down the price in the United States. This caused many companies to go bankrupt. Once this initial boom is over, the price will gradually balance out and continue to grow.

Now it has been proven that these reserves are real and can be used, but for how long it will last, and what will happen when they have run out is hard to say. It is still very uncertain how much can be used of the large reserves.

In Europe the situation is even more uncertain. It has been discussed on how reachable reserves are here and sometimes there have been speculations that it is possible to utilize, when in cases it has been said it isn’t or then that permission won`t be given to start production. But we don’t believe it will ever be on done in Europe at the same extent as in the US and for example in Algeria we don’t believe it is possible for them to start adding production.

7. Nuclear power

I have to say about nuclear power that the uranium reserves today won`t last any longer than for example natural gas reserves. The reserves are about the same as oil and natural gas in terms of how many years we can still use it. The only way we can make it last better is to improve the technology. If we could start using breeder reactors where the utilization of uranium is close to about 100 times better than traditional reactors, which can only use the uranium 35 that is only about 10% of the total uranium, the sustainability would be much better. If we could use this lower quality uranium it would also mean we would that the useful reserves would be much greater as there is much more low quality uranium in the world. It has also been speculated that at this point we could even use uranium separated from sea water which would mean that there would be close to unlimited supply.

Fusion reactors are another possibility which would mean close to unlimited supply and would at least give enough time for people to invent the next possibility. The old joke about fusion energy though is that it is always 50 years away. Some estimates come as close as 30 years but there are no plans that would bring it closer.

The good thing about fusion energy compared to breeder reactors would be that it is not connected to nuclear bombs and wouldn’t bring that issue. Breeder reactors also don’t solve the problem of nuclear energy that it is very dangerous and requires extreme caution to avoid disasters.

Modern nuclear energy is pretty good just as long as it is used correctly. The problem is that can you be sure that it is used correctly. The biggest problem is that nuclear reactors are extremely hot and stay hot for days, weeks and using breeder reactors even years and if there is a fault in the system they have to be cooled down constantly. For example what happened in Fukushima was that when the tsunami hit the reactors went off, but it still stayed hot and the precaution measures weren’t enough as electricity cut off and the plant was inaccessible because of floods and radiation. Fusion energy doesn`t have this problem as when it shuts down, it shuts down. The problem is that it making it happen is so hard that there are still no guarantees that it will ever come. But as it so promising it is still worth trying to develop and continue research. Research in fusion is still progressing, but we cannot rely on it ever coming.

Comments

Based on Pekka Piriläs answers it seems that the best option will be for us to start using a suitable mix of all resources and not focus too much on one source of energy. It is also important to consider what is regionally wise to use. In countries like finland it is a good option to develop technologies which utilize our regional abundancies for example organic materials.

At a global scale the only real savior of an energy crisis is based on nuclear developing fission reactors to use lower grade uranium. Another option would be fusion reactors which could give a close to unlimited source of energy.

Q8: Do you think it will be possible that natural gas could be used more in transportation as an alternative to oil?

A8: I don’t believe it is likely that gas will be used in large scale. I see synthetic oil as a more likely form of fuel for transportation.

I have been in a taxi myself in Cairo which ran on natural Gas so there are places in the world where cars are run by natural gas, but even in this country where safety doesn`t always come first, there where special rules and a restricted area around the gas pump as natural gas distribution has its own risks.

Q9: If you should choose one alternative energy resource which would be good for Finland what would it be?

A9: I believe the big question instead would be how much can we cut down energy use and make everything more efficient. The main energy consumer in Finland is the industrial sector. After that comes heating and transportation.

In Finland, the industrial sector is deeply connected with natural resources. For example the forest industry uses wood, which is not an energy intensive industry at a global scale, but uses a lot of energy in any case. The other industry which uses a lot of energy is the metal industry for example Outokumpu near Tornio which is close to chrome mine.

If we want survive economically in Finland we can`t choose our own industries. If someone needs metals or wood products in the world, Finland is a good place to produce it. So these will most likely also be produced in the future even if there would come some new solutions. How much energy is used for the production, is key to how development elsewhere is possible.

Household energy efficiency has improved a lot and has had a positive trend and it looks like energy use has strong potential to be cut down. These days it is possible to make a very livable household which is very energy efficient. They have good insulation, tight structure, well designed and preserved ventilation. With these changes we can cut down the need for heating to a fraction.

Then in the traffic sector, as oil looks like it is going away there are many different options to the current system. There is the possibility of the change in the entire traffic structure. We the modern traffic structure change entirely? Could there be some in between solution combined with mass transport? A somehow attractive solution could be that we wouldn’t drive alone in cars that way a ton, instead there would be light transportation vehicles which wouldn’t necessarily move independently, but we would still have our own vehicles which we could leave home with. They could possibly attach to some kind of train of track which could then transport it for the longer distance from the suburbs to the city. Another option could be that we would leave our homes with electric cars. Drive onto some vehicle transportation train from the suburbs which would then take us to the city where again we can drive to our destination with the small electric car which doesn`t use a lot of energy.

Comments

This is an interesting point of view how we could make our transportation system more efficient. Could the transportation system change entirely. How could adapt these kind of new innovative ideas? Could it be possible do make these changes in already developed countries or is this more of an idea for developing new areas like the new megacities of china built from scratch.

Q10: As these kind of structural changes require time and money, should for example the Finnish government start prepare for the change now instead of waiting for a crisis to happen?

A10: Well it is hard to start building these kinds of systems, but one thing that should be thought is planning the urban structure. It should be planned so that it wouldn’t prevent the renewal of the system. Of course it doesn’t have to be exactly be the example mentioned earlier, but as an example that something totally different could be the future, which could have benefits from both the old and the new system.

Another thing that will change the system will be online services and how it will change the behavior of people. What will be the role of distant working which hasn’t yet lifted off as it could? Also if the price of fuel goes up dramatically and affects the aviation industry, what will it do to tourism? Will travelling be replaced with surfing online? These are possible things that may affect the need of transportation. As cars will most likely stay for quite a while, will there be a transformation to hybrid or electric cars? It seems that the direction seems to be that way but one possibility also is moving towards synthetic fuels which are produced one way or another. For example hydrogen is one possibility. It seems that the future is likely to be powered by renewable resources and possibly nuclear if it stays strong and as an additive there would be synthetically produced fuels.

Comments

It is interesting to notice that Pekka Pirilä`s answer mentions that urban structure would be good to plan. Comparing to the expert in the ministry of employment and the economy who says compares urban structural planning to what the Solviet Union and mentioned that people are not willing for chages. In my opinion people would be ready for change if it would be encouraged by tax reductions or other benefits such as cheaper public transport etc.

Q11: What is your guess that Finland would not use crude oil anymore?

A11: I think oil and gas will be used in some way or another for a long time to come, but around 2050 I think consumption it could be at a very low level. Using oil in a small scale has very little harm and producing oil from for example oil shale will be done at some scale for a very long time. As oil shale is hard to reach the production cannot reach a high volume which is why it will last for a long time. The same thing goes with coal which will also last for a long time when used in a low volume.

I don’t think we will meet the same growth rates of oil production and consumption that we had in the before the 1970`s oil crisis as the exponential growth was just impossible to continue. Lower levels of growth and then eventually a slow decline is possible. But at this rate of growth of human population, especially in countries with large populations want to raise their standard of living, there will come a collision. One way or another it will have to happen. Worst case scenario it will be a catastrophe of some sort, will it be war or some regional crisis. You have to be optimistic to believe that everything will go smoothly and there won`t happen anything very serious somewhere in the world. A currency war is something that will happen this century and countries like China and India where there are over a billion people and growth there might become a conflict between hopes and possibilities. If we survive until 2100 without anything serious then things might look a bit brighter for the future.

Comments

Pekka Pirilä addresses that if things do not change, it is ievitable that we will hit a collision. This is to some extent in line with the Oduvai Theory discussed in Chapter 3.2 as for even though Pekka didn’t directly address that the collision would happen because of scarcity of the energy. On the other hand as long as we have “cheap” energy it is practically possible to overcome any resource limitations.

8. CONCLUSION

Peak oil as a phenomenon has been a very interesting subject to study as it has such wide spread effects on every part of living and well being in the world as energy is the power that makes the modern world work as seamlessly as it does in developed countries. Oil itself is the most powerful resource we have today as it is energy dense, applicable it many different ways and easily transportable which makes it the clearly the most valuable source we have.

Through this study we have found out that conventional “cheap oil” seems to have seen its final years as prices have gone up and stayed up even though the economy has been in depression. Oil can still be produced at a high level for the nearby future but financial restraints will make it harder to get. The problem nation’s face is that the developing countries are demanding ever more energy to keep up with the growth which makes it harder for countries like Finland to pay for it.

In other words conventional peak oil has happened or is happening right now and we have to start using other substitutes to cover the loss. Unconventional oil has shown it can be put to use and at the moment is valuable and profitable to use and most likely will become even more important for us in the future. Until we find another solution we will just have to learn to do with less energy and try to invest in alternative options to broaden our energy mix. The less dependent we are on oil in the future the easier it will be for us.

The most visible consequence of peak oil have been that oil drilling has started in areas it was not profitable to drill before and using different means to obtain fuel, for example, by manufacturing synthetic oil. Other consequences will be risen oil prices and risen prices in general. These will not be immediate consequences and will highly depend on the supply and demand of oil. All in all the current consensus, if environment is left out of the equation, as long as oil price can be kept in a reasonable level there will be no major upheavals in the energy industry driven by the possible need to force quick transition to alternative energy resources. It is recognized that at some point this will be necessary but without a clear way to measure and to know when this should be done there is no desire, as stated, to force the matter.

The effects peak oil will have in Finland will be that we will have to make do with less easy and cheap fuel. Unless there is a sudden shock in the availability of oil it should be a slow decent to other forms of energy. This means life will become more expensive and we might have to adapt to new ways of living. It would be unrealistic for the Finnish people to expect radical changes to come from the governmental and main stream politics before there is a real crisis as the political itself will turn against it. There is money in energy and using more of it means more jobs and more money. Saying that we have to start saving money and living at a slower pace does not bring votes thus we will be in this same situation until there is a crisis.

The positive effects Finland will face due to energy scarcity in the world is that high tech energy efficient systems will have a growing demand in the future which could bring new possibilities to the Finnish high tech industry. In my opinion Finland should start investing its highly educated workforce into this industry as unemployment in traditional industries are on the rise without any ease in the nearby future. By developing Finland's own industries to be highly efficient and innovative in this sector we could grow our technology to be ahead of the game and sell our ideas abroad.

The alternative for the energy sector is to focus on spreading out our energy production to an efficient mix of different kinds of resources and cutting down our dependency on fossil fuels. At the same time we need to think of new solutions how to make our transportation sector more efficient as there is still no obvious savior in this field. Public transportation needs to be taken to another level and the community structure has to be planned according to future needs instead of convenience. The structure has to be built so that we could adapt to new solutions instead of holding on to the old.

As Finland is still very dependent on other countries in terms of energy we need to focus on how we are going to improve our self efficiency. Nuclear power is a good option for Finland as we are a stable country politically and geographically. Finland also has high reserves of wood and organic fuels which can be developed into synthetic fuels. This will be critical as the crisis we could face in a sudden oil shock would especially mean the price of liquid fuels will go up and availability from abroad will go down.

Subjects for further study

EROEI came up in one form or another as being the only method that counts many parts of sustainability instead of counting the profitability. There is a high need for a commonly accepted methodology to be developed which also counts in factors such as environmental and sociopolitical value additional to the sustainability both energy and money wise. Developing a new method for this would be key to understanding future needs and sustainable ways of producing energy. If EROEI could be developed into a reliable methodology its applications would be limitless and we could truly calculate what will be the right time to transfer to other resources instead of wasting money on something that won't be profitable in until far in the future.

Another subject for further study would be how long the structural change into another fuel for transportation would take. For example how long would it take for a country to change to use a new source of fuel like hydrogen fuel cells. Or what changes would have to happen if oil consumption would be forced down by 80%.

One interesting subject for further study would also be to deepen into the psychological side of how people react when they think about peak oil and what effects would follow. We have noticed when discussing about the subject with many different people that practically everyone agree that oil will finish in the near future but they don't want to accept the peak oil theory. Even highly educated, especially middle age people who have grown up during the time of cheap oil do not want to accept it and do not even want to consider it as a possible outcome.

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