GETTING THE MOST OUT OF ALBERTA'S TAR SANDS

A "WHITE PAPER" FOR DISCUSSION

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INTRODUCTION

I am here to present you with a proposal for an optimized model for the exploitation of the tar sands. Although, the tar sands are a non-renewable resource, they contain more oil than all the worlds currently known reserves put together. (174 billion barrels close to the surface – second only to Saudi Arabia, and another 1.6 trillion barrels deep underground). Our society is committed to exploiting this vast resource, and pilot projects have operated during the last 40 years. Now an explosion in interest, investment and licensing is taking place, and therefore it is becoming imperative that policy decisions are made to define the goals, the targeted rate, the method, the sustainability, and the acceptability of the consequences of such an exploitation process. The proposed model intends to address these issues; however, let me take you through the thinking process that has resulted in the conclusions of the model presented.

If you get a string and fold it twice you get 4 strings. If you twist it to make a rope and then apply a force you will find that the strength of the string is no longer equivalent to four strings. It is more than four strings. The extra strength comes from the **synergy** of the four strings working together. The same principle applies to an electronic board, where the strength of the board is far greater than the sum of the individual strengths of the various resistors, capacitors, transistors etc.

The concept of synergy can be extrapolated to human beings. For example the higher the synergy of a sports team the higher is the strength of the team relative to the sum of the strengths of the individual players. The synergy concept can be expanded to companies, industries, cities and countries. Empires were formed when they achieved high levels of synergy and collapsed when for some reason their synergy collapsed.

In Alberta, we have a Province that exports a great deal of energy, yet there is not a synergy that would optimize, maximize and extend this resource. The main reason for writing this paper is to address this problem.

The oil industry has reported that it costs $10 to produce one barrel of oil. This statement has been based on an economic analysis (cost/benefit) performed by the oil industry. However, cost/benefit audits are not necessarily limited to financial nature only. For example energy audits will define how much energy we input for the production of a barrel of oil and how much energy we get out of it when we consume it, or how much energy goes into producing hydrogen and how much energy we can get out of this product. Similarly, resource audits will define the relative amount of resources consumed per barrel of oil produced and thus optimize the production process, in order to conserve our resources. An environmental audit will define the type of feedstock or energy source that is preferred in order to minimize the pollution to our environment. A Semi-financial audit would also evaluate things like the cost and energy of oil and gas used to produce some fertilizers, pesticides and herbicides against the improved quantity and quality of crops, and hence lower commodity price to the public.

Audits are different than studies. During an audit one compares one parameter against another and derives a conclusion based on actual facts. Studies usually are selective and biased in line with preconceived beliefs. Someone selects only points which support his preconceived ideas, Based on this he draws his conclusions which can change subject to interpretation.

The list of possible audits seems endless, yet we, the public, have been informed only of the financial audits and some environmental studies performed by AEUB (Alberta Energy Utilities Board) and oil companies for their own use. Let me interject here that oil companies are not meant to be charitable organizations. They are profit-making machines for their stockholders. That is their purpose and that is why we have them. They are tools of our economy, and this is the modus operandi of capitalism –the system that we have chosen to live in. It is not the job of the oil companies to produce studies, which are not directly related to their goals. Some of you might have read about the stockholders back in 1919 that took Henry Ford to court for raising the minimum daily wages to $5/day, and won their case.

With regards to the Tar Sands exploitation process, the question that I am raising is that “if the oil companies are not obliged or responsible to perform audits not directly related to their purpose and if AEUB (Alberta Energy Utility Board) has limited its expertise and focuses only on reacting to the oil industry’s activities, then who is responsible for initiating and performing independently the various necessary audits that would result in an orderly, optimized and sustainable form of exploitation?" Prior to issuing a production lease and permit, as a minimum, I can think of at least four areas that should be audited, in addition to the economic audit. These include: Environmental, Energy, Conservation of precious resources and Water availability audits to ensure that not only the oil companies are benefited but also society as a whole.

These audits in more detail are:

Environmental Audit: The oil industry is doing a fair job in restoring the disturbed land. They replant trees and restore grasslands; they release buffalos, etc. This restoration however covers only 20% of the disturbed land, based on oil industry reports of land used and land reclamation rates. In addition, there are left behind settling basins and toxic ponds at an increasing rate. It is reported that there is enough water in these toxic ponds to fill Lake Erie. Yes, Lake Erie is a shallow lake, and this is likely an exaggeration by environmentalists, but the meaning of this message remains the same. Meanwhile, the price of oil has increased from $30/barrel (when the financial audit was performed) to $70/barrel. The targeted volume of projected oil produced, has also more than tripled for the next 10 years. This means that both the oil company's profits and future royalties to Governments will likely more than double. Consequently, there should be plenty of available money to finance solutions to the above-mentioned problems. What does it take to establish an infrastructure and set targets to be met? What kind of technology should be used to stop the creation of toxic ponds? The tar sands underlie ¼ of the area of Alberta. The oil companies mine 2 tones of tar sand per barrel of oil from pits down to 200 ft deep. These scars, according to environmentalists, are large enough to be visible from the moon. Our Government is accelerating the issue of permits and leases to the oil companies, while nothing is there to indicate that the overall potential for environmental problems is acknowledged or addressed by anyone. The cost of restoring the land represents less than $1/barrel produced. Yet, when the feasibility stage of the development was completed, the price of oil was about $20 per barrel and the volume was that of a pilot plant only. Now the price is at $60/barrel and the volume of oil produced is multiplying exponentially, along with the environmental gap. It does not seem to be appreciated that what was an acceptable environmental impact during the developmental scale of production is not acceptable and it can be disastrous under full production scale. Not addressing these problems now, raises the possibility of a damage of gigantic proportions. Is this acceptable to our Government? Is this what we plan to leave for the next generation of Albertans?

Resource and Energy Audit: The oil industry reports that it consumes 1000 cubic feet of gas for every barrel of oil produced. Some of this gas is burned to produce heat and electricity and the rest is stripped of its hydrogen to help convert the bitumen into crude oil. Both these processes are consuming surplus natural gas as if it was a by-product of very little value. Instead of burning it up in stacks (flaring it) they use it. From the resources point of view we are burning a valuable and relatively cleaner form of energy to produce a more polluting fuel. From the economic point of view, we are squandering a resource that will be needed for a long time to produce fertilizers and pesticides for our agriculture, (our food). From the energy point of view how much energy is consumed to produce one barrel of oil (and also how much more potential energy is wasted) and how much energy do we get out of it when we consume it.

Another process used at the tar sands removes some carbon from the bitumen in order to enrich its hydrogen content and to produce crude oil. This process produces a large quantity of Coke and Asphaltene as by-products which are both accumulating on the site, instead of enriching them with hydrogen and thus producing more crude oil per unit of bitumen.

A Syncrude executive stated last June (the Globe and Mail) that if we want increased production of oil we would have to accept increased rates of release of carbon products to the atmosphere. Is this correct? Should we then assume that there is no alternative, or is this how an oilman sees it. We should not expect the oil industry to look at other forms of energy on its own. However, an unbiased, balanced and well-informed audit could provide much different conclusions and efficiency in resources and energy used up in the tar sands. Who is examining for alternative sources for energy and for hydrogen production and how can we provide an incentive to the oil industry to adopt the needed changes?

Water availability audit: Based again on oil industry reports, it takes about 3 barrels of water to produce 1 barrel of oil. Even if some water is recycled it still makes a great impact on the availability of this resource. Right now Syncrude gets about 1% of the average annual flow of the Athabasca River. (It actually gets more water but it returns a portion of it back to the river along with some contaminants). Considering that the Syncrude process consumes half as much water/barrel produced than other companies, when all the newly issued permits have resulted in producing oilfields, the removal of water from Athabaska will likely exceed 10% level of its average annual flow, within the next few years. Such an impact will take place while the tar sands development is still at its infancy level. What will be happening when it reaches maturity? What will happen if the natural weather cycle of our planet reduces the amount of water available in this area? The oil companies are spending a great amount of capital up front. We cannot come afterwards and tell them that there is not enough water for them, to continue with the production process, for which they have been licensed.

In this paper the audits for energy, resources and environmental analysis have been performed qualitatively and quantitatively based on reported or derived data. These audits, although not exhaustive, were performed to a depth level sufficient to reach some conclusions. For the water availability audit we have just scratched the surface, as this topic is beyond the capability of the author. There will be needed a major undertaking of a multidisciplinary group to address this area and to establish the forecasted quantities of available water, and hence to adjust the rate of demand. Perhaps, a water pipeline and/or desalination might be needed to ensure water sustainability in the tar sands development.

This paper also includes an analysis of alternative available energy forms, available world oil pools and consumption rates, an analysis of the claims for atmosphere warming gases, a novice evaluation of nuclear power, and it places the hydrogen dream into perspective.

As mentioned above, our society is committed to exploit the tar sands. To build an oil field, an oil company is making a large initial investment in an installation that remains a producing asset for about 30 years. Therefore it becomes vulnerable to changes. On the other hand we have proponents of different forms of energy, which resent the oil industry, and conversely, the oil industry considers as competition any other forms of energy. On top of this chaos we have groups of environmentalists, some of them informed some others misinformed and dreaming. Under these circumstances, it is natural that the seriousness of these environmental problems or the introduction of different forms of energy is vigorously debated by the oil industry. Are the risks greatly exaggerated or conversely are they underestimated? This is what this paper is analyzing.

Following this present auditing process it was concluded that all these conflicting positions are not only wrong, but also that they serve no one. In fact I can argue that in reality there is no conflict for the long term, as well as for the short term. The interests of all alternative energy proponents, those of the oil industry, those of the environmentalists, those of the Government and those of society as a whole, can be made to coincide. One has to look at reasonable incentives for each group, both short and long term and to try to accommodate them. This, I believe, is the intent and the purpose of the proposed model.

If this model is implemented, the Governments of Canada and Alberta will be called to make choices that will depend on the courage to practice long-term thinking and to make bold, courageous anticipatory decisions at a time when problems are perceptible but before they have reached crisis proportions. If successful in convincing you of the benefits ahead, I believe that Alberta, based on the timely and strategic strength of the tar sands, will be spearheading a new era where society will be able to continue its growth uninterrupted, where a lot of environmental problems will come under control, where alternative energy proponents will have a chance to contribute to an increasing energy thirsty world, and where oil companies will secure a healthy growth in the production of hydrocarbons, while they begin to view themselves as energy providing companies for many centuries after the depletion of the hydrocarbons. This is expected to bring a real prosperity of a very long duration to our Country and our Province.

While performing the audits for this paper, we discovered one of the greatest forms of pollution; greater than green house gases, greater than the Chernobyl accident, or the Exxon Valdez oil spill. As the information technology is expending the amount of "misinformation" has literally exploded. This is the real pollution. Theories are repeated until they are perceived as facts. Catch words become current important topics. The confusion permeates across all segments of our society, and although we debate things to death, we seem to draw a lot of conclusions on misinformation. This is becoming our biggest enemy.

To avoid repeating misinformation, this paper has limited itself to drawing conclusions only based on undisputable facts. It was prepared without any loyalty to any particular industry, government or sector of society. We do hope that this goal has been achieved.

PART 1: THE ENERGY DEMAND PICTURE

1.1 THE ELECTRICAL DEMAND – THE WORLD

The world's demand for electrical energy in 2005 was 320 billion kWh/day. This translates to a built capacity of power stations of about 16 billion kW, including stand-by capability. To put it further into perspective, this capacity of power plants can be achieved by either one of:

a) 8 million wind mills the size of the ones we have in Alberta running 24 hours/day year round

b) 16,000 to 20,000 large power stations of coal, oil or nuclear fired plants running continuously

c) 2 trillion square feet of solar panels assuming that the sun shines every day

The problem is not only that these numbers are very big. World demand for electricity is increasing so fast that these big numbers are doubling themselves every 55 years. This means that during the next 55 years we will have to build about 40,000 new power plants. 20,000 new ones, plus 20,000 more stations to replace the currently aging power plants (the lifetime of a power plant is about 40 years). We will need to build on the average about 750 large power plants per year over the next 55 years. The investment associated with such a growth, calculated at an average of $1.5 billion per plant comes to about $1.125 trillion per year for the next 55 years, (in 2006 dollar value).

1.2 THE ENERGY DEMAND FOR TRANSPORTATION AND INDUSTRY NEEDS

THE OIL PICTURE – THE WORLD

The world's demand for oil in 2005 was approximately 80 million barrels/day. Here again, the problem is not only that this number is very big, but also, that our demand is increasing so fast that it is to double every 40 years. The recent price increases of oil did not happen because we are running out of oil. Not yet. It has been because the increase in the production capacity of crude oil is not keeping up with the increases in demand. In 40 years we will need 160 million barrels/day, and perhaps in 80 years it will be 320 million barrels/day. The capital investment that will be needed by the oil companies to meet this demand becomes astronomical. In the tar sands it currently stands between $7 and $11 billion for a production facility of about 100,000 barrels per day. This variation depends on the duration and timing of the construction project. We will get to this later.

From the 80 million barrels of oil consumed by the world per day, approximately two thirds is used to make fuel for cars, trucks, airplanes, farm machinery, and construction equipment. One third is used to make car tires, plastics, and industrial products. This industrial demand (which represents one third of our consumption now) is increasing at a higher rate than the demand for transportation fuel oil. New capital projects undertaken for the increased production and refining of oil, as well as new capital equipment and construction for new power plants, plus the increased need of industrial plants needed to manufacture the needed equipment all require oil for the energy required to built them. If we add all the additional industrial demand, over the next two decades, the increased demand for (a) alternative power sources, (b) power plant components (c) metal mining, refining and processing, the projected industrial demand will easily become 50 to 60% of the total oil consumed in 2006.

THE GAS PICTURE – THE WORLD

In addition to oil, in 2005 the world consumed 2.7 trillion cubic meters of natural gas. The demand for this commodity is increasing faster than either oil consumption or electrical demand. The demand for natural gas is doubling every 30 years. The USA again consumes about ¼ of the world's total. Natural gas is used for electricity producing power plants, for making fertilizers, pesticides and herbicides for agriculture, for residential and industrial heating, and for an extensive inventory of other industrial applications. The above stated world consumption of 2.7 trillion cu ft. does not include a significant amount of natural gas that is either wasted by burning it up in stacks in refineries and in oil producing wells, called "FLARING", as a by-product of oil production, or by burning it at the tar sands sites for the production of electricity, heat, and steam needed for the production of oil called "UTILITY GAS", or by stripping the hydrogen out of the gas for feed in the "hydro cracker" and "hydrotreater" plants, again for the production of oil. Natural gas is the cleanest form of hydrocarbons when burned. However, both processes burning and stripping produce a lot of CO_2 that is released to the atmosphere. It is reported that the oil industry is using about 1000 cubic feet of natural gas for every barrel of oil produced.

1.3 CONCLUSION ON ENERGY DEMAND

Based on the above rates of consumption, as well as the rates of increase of this consumption, it seems that humanity's current way of life is heading in a collision course with geology. Such an accelerated pace of consumption is clearly not sustainable.

In the Times best seller "Collapse" Jared Diamond suggests that our problem is not only that the human population of our planet is increasing, it is not only that the average age of human beings is getting longer, it is also that the so called third world countries, desire, aspire and are working towards achieving a first world status quality of life. These three put together place an enormous impact on our resources, and as we are using them today (major squandering), simply put, it cannot be sustained. As an example, during 2005 two million new cars were put into the streets of China alone. This rate increases the number of Chinese drivers at a rate of about 70% per year.

While analyzing and evaluating Jared Diamond's point, the following proof was obtained: The USA presently is consuming 25% of the worlds produced hydrocarbons, yet it comprises only 5% of the word's population. This high consumption rate is almost necessary in order to maintain a first world status and quality of life. Similar level ratios apply to all developed countries. For the rest of the world to achieve a similar first world status, today's demand of 80 million barrels/day becomes 1,200 million barrels/day i.e. 15 times. This kind of exponential increase in the demand clearly is not sustainable and indeed confirms a collision course with geology. The same analogy applies, whether the analysis includes hydrocarbons or electricity demands.

The above conclusion makes it obvious that our world either will have to slow our progress considerably and hence the improvements in the quality of life of all humanity, or otherwise we will have to find more efficient ways to use our resources. This in turn, leads us to the thought that if we could start soon to include an optimized use of alternative energy forms, perhaps we could sustain our growth rates and quality of life. Whether we recognize it or not, this is not an issue of "if we want to", we have no choice in this matter. Similarly, we have no choice on whether we like some or all-alternative forms of energy. We do need them all and very urgently. The only choice that we have is to decide whether we want to survive and to define the applicability and proportion of each energy form.

Of course, the talk of alternative forms of energy is an anathema to the oil industry. They have spent billions of dollars to develop oil fields around the world. They are planning some 100 billion dollars of new capital spending on the tar sands this decade to establish cash producing assets. Their fears should be understood and appreciated. However, as we will see further on in this paper, not by choice, but by necessity, we will have to continue using an ever-increasing amount of hydrocarbons for several decades even if we chose today to branch into other forms of energy. Recognition of this fact hopefully should ease the oil industry's fears and make them more cooperative to the idea of timely change of energy infrastructure.

Let us assume for the moment that there is a technology that we can change to, for our future electrical energy needs. The change over period will involve a long fifty years, just for this change to be completed. We will have to replace all the currently operating power plants, which due to limited capacities for construction and manufacturing will take about 30 years. Then we will have to build the additional capacity to meet the increased demands of humanity that we will be experiencing in 30 years from now. This will take another 20 years to complete.

We must appreciate that it will take a lot of extra energy to change our current energy infrastructure. Much of that will come from the burning of hydrocarbons. The quantity of resources that will have to be mined, transported, and processed and the industrial demand for energy over and above the normal demand will need oil. This will push to the limits all existing and planned expansions of the oil industry over the next 50 years and more. The cost of construction of oil fields, up in the tar sands has gone from $7 billion to $11 billion for a facility that produces about 100,000 barrels/day. That is because of the limits in our capacity to produce faster. This results in longer construction periods and delays in manufacturing, both of which increase the costs and the interest carry over (see 3.2 (a) interest carry over). Right now, there is a waiting period of two years just to get delivery of the components to construct a simple windmill, like the ones we have in Alberta.

At this point in history we know that sooner or later a day of reckoning will come. Hydrocarbon-based products and plastics are used for manufacturing our industrial components. Hydrocarbons are burned to mine and transport resources and to build our industrial facilities. The picture should be clear. A vastly increased amount of oil will need to be consumed in order to create and build the new energy infrastructure while meeting the current energy demands and phasing out the old infrastructure. The higher the price of oil is the more expensive becomes the option of changing our energy infrastructure. Conversely, the less time we have available to construct the new infrastructure the higher its cost will be. We witnessed this recently with the skyrocketing costs at the tar sands.

The same story unfolds for the transportation industry. If we start converting private cars today, to other forms of energy, the consumption of oil will not go down. It will go up until the new infrastructure is built, the change over becomes entrenched and old cars are phased out. It is estimated that just to replace the supply side requirements of gasoline in the US for private cars; it will take an investment of at least $2 trillion. How much of this amount will be for the cost of energy, and how much of this energy will come from hydrocarbons?

One third of the hydrocarbons consumed today go to make some 500,000 industrial products. This demand will be increasing and doubling on the average every 25 to 30 years, during the changeover period.

11,000 airlines in the world will need a long time to replace all their airplanes to burn the new fuel. A long time and vast amounts of oil will also be needed to convert not only the supply side of the new fuel but also the consumption equipment: cars, industrial machines, trains, ships all of which are designed to burn petroleum products.

Look at what happened in the tar sands by pushing a relatively modest increase in demand for new construction, while we still have available a reasonable amount of construction capacity. The price for a 100,000 barrel/day plant shot up 57%. What will happen when the last minute we realize that we need to change our entire energy infrastructure on a panicky basis?

Based on environmental, financial, energy and resource points of view, there is no incentive to change only car fuel while we continue to burn coal in our power plants. The earlier that we start the changeover process for our energy needs the easier and cheaper it will be. Attacking the forthcoming energy crisis with a better light bulb or conservation seems to me more like an unrealistic dream.

If one looks at the oil industry more carefully, instead of avoiding other forms of energy, oilmen have the incentive to encourage the introduction of new energy forms, because this will guarantee them a continuation of growth over the next 50 years, and a slower but steady and manageable increase in demand thereafter, until hydrocarbons are depleted.

I have calculated that for humanity to change its energy infrastructure we will need to use an approximate amount of 150 billion barrels of oil equivalent and an investment of 120 trillion dollars (2006). The change over time will take about 50 years.

(*DEFINITION: Depletion of hydrocarbons is defined for the purpose of this paper as the time at which the lifetime of an oil field will be less than 30 years, and thereby will not be economical to develop*.) Furthermore, an explosive growth in the demand for the new form of energy is guaranteed over several centuries.

This new form of energy will present a new market that will require the size, ability, management skills, deep pockets and infrastructure similar to that of the oil companies.

In summary, we are riding on a time bomb. We are experiencing a high demand for all forms of energy and that demand is increasing exponentially. We know that our current resources of hydrocarbons will sooner or later be depleted. We also know that we will need an enormous amount of extra energy and about 50 years to change our current infrastructure and our dependence on hydrocarbons. That energy at this point in our history mostly comes from hydrocarbons. Approaching depletion before we start looking for alternatives is clearly the wrong way. The only encouraging indication that we have had so far comes from the oil company B.P. They have started interpreting B.P. to mean "Beyond Petroleum". This is not enough. We urgently need to form and implement a plan of action.

PART 2: THE ENERGY SUPPLY PICTURE

2.1 ELECTRICITY PRODUCING POWER PLANTS TODAY

The types of electricity producing power plants, which are available today, include four types of mature energy technologies and four developing technologies:

Mature Technologies

1) Hydroelectric energy: Product of rain cycle – Primary heat source the sun's nuclear fusion

2) Coal Energy: Product – fossil of photosynthesis over thousands of years-primary source sun's nuclear fusion (1)

3) Natural Gas: Product – fossil of photosynthesis over thousands of years-primary source sun's nuclear fusion (1)

4) Oil Energy: Product – fossil of photosynthesis over thousands of years – primary source sun's nuclear fusion (1)

Developing Technologies

5) Solar energy: based on photovoltaic conversion – primary photon source, the sun's nuclear fusion (1)

6) Biomass: based on photosynthesis over one year – primary source the sun's nuclear fusion (1)

7) Wind power: balancing the earth's differential heat absorption – primary source the sun's nuclear fusion (1).

8) Nuclear energy: product of earth mined nuclear isotopes- primary source

man made nuclear fission (2)

Notes:(1) nuclear fusion: the combination of hydrogen atoms to form helium (sun)

(2) nuclear fission is the breaking of a heavy metal atoms (mined on earth)

All of the above plants are based on proven technologies. Plants belonging to mature technologies are the predominant producers of electricity today, while plants belonging to developing technologies produce a small fraction of the world's electricity demand. Note that regardless of which technology is used for our power production, all are based on some primary form of nuclear reaction. An interesting form of energy has recently been developed at the tar sands (Syngas) but this can only be used in the tar sands context.

2.2 ECONOMIC ANALYSIS OF AVAILABLE POWER STATIONS

Some plants cost more to construct while others cost more to operate. Similarly, some plants are more efficient at producing electricity than others. The way to calculate the cost/benefit of every plant is to obtain the total cost of the plant by adding:

- The capital cost to construct the plant
- The cost of money during the usually long construction process – called "interest carry over"
- The cost of the fuel it burns
- The operating cost of salaries, maintenance and repairs
- The cost of pollution it causes
- The cost of decommissioning and
- Overhead costs

A power plant usually has a lifetime of about 40 years. It produces power for 40 years minus the down time for maintenance, repair or refueling. The electricity it produces over its productive lifetime is calculated in terms of kilowatt-hours (kWh). This means kilowatts produced over the total operating number of hours. Then the sum of all the costs above is divided by the sum of all the kWh produced to obtain the cost/kWh of every plant. This number is very important in order to compare the cost of electricity produced by the various technologies, because as we will see below, there is a great variation among the various plants with regards to capital and operating costs, as well the efficiency with which they produce power.

Prior to 2005, when the prices of oil increased, and the enforcement of Kyoto protocol created the carbon market, the relative cost /kWh of all these plants were as follows, listed with increasing cost:

Hydro power plant	5.0	cents/kWh
Coal fired plant	5.5	cents/kWh
Natural gas	6.0	cents/kWh
Biomass fuel	6.5	cents/kWh
Oil fired plant	6.8	cents/kWh
Wind power	7.0	cents/kWh
Nuclear	7.0	cents/kWh
Solar power	23.0	cents/kWh

At first these numbers would be surprising. For example, how can solar power cost so much more since the sunlight is free, or how can wind power be the same as nuclear since everybody is told about how expensive nuclear power is, while again the wind is free. The answer for the former is that the capital cost of solar panels is so high relative to the power they produce that it takes all their operating lifetime to pay it back. With regards to the later, nuclear plants produce electricity with such high efficiency and so low operating cost that it negates the high original capital input costs. A detailed analysis is provided later in this paper.

After the prices of hydrocarbons increased (doubled) and the Kyoto Carbon market came into effect the relative cost/kWh became as follows, listed again with increasing cost:

Plant Type	2004 Price cents/kWhr	Fuel cost increase***cents/kWhr	2004 carbon cost*** cents/kWhr	2006 cost cents/kWhr	Carbon producedGm/kWhr
Hydro	5.0	2.0	0.24	7.24	60
Nuclear	7.0	0.5	0.02	7.52	5
Wind	7.0	1.0	0.04	8.04	10
Biomass	6.5	2.0	0.06	8.56	16
Coal	5.5	4.0	1.40	10.90	350
Nat. Gas	6.0	5.0	0.72	11.72	180
Oil	6.5	4.5	0.96	11.96	240
Solar	23.0	6.0	0.24	29.24	60

Table Notes:

**** Different plants require different amounts of oil for their construction and operation. For example a hydro plant requires a great deal of work by bulldozers to move earth and to build the* *dam. Bulldozers burn oil. Similarly biomass plants require the use of fertilizers and pesticides, both of which are product of hydrocarbons. To mine and transport coal again, requires an extensive amount of oil. Hence these plants are sensitive to doubling of the price of oil. This relative sensitivity is listed in column #2. A high price jump is observed in the fossil fired (coal, oil & gas) power plants. Notice that natural gas plants are more sensitive to oil price increases than oil fired plants. This is because gas plants have lower capital construction costs and hence a relatively higher operating cost/kWh than oil.*

Column #3 shows the additional cost that is imposed by the Kyoto protocol for the so-called "Carbon market". This is why lobbies in the USA have caused the USA to abstain from signing this protocol. For the last 25 years the USA has relied heavily on coal-fired plants, which are the highest polluters. The prices listed in column #3 were calculated more than a year ago. Since then the carbon cost has increased by 500%.

Column #4 shows the relative total cost now. It includes: the cost of the power in 2004, the additional cost/kWh that would result from the increased price of oil and the cost of pollution.

Column #5 lists the pollution that is released to the atmosphere as grams of CO2 per kWh of electrical power produced. It is interesting to note that solar power is more polluting than Biomass, Wind or Nuclear are equally polluting as a Hydro plant that requires the burning of an extensive amount of oil to build the dam. This is because as we will see later, the existing solar panels are very inefficient converters of energy. Column #5 also includes additional information relative to the energy input for both the construction of a plant as well as its operation. CO2 is produced when we consume hydrocarbons to produce energy. The relative amount of CO2/kWh is directly proportional to the energy equivalent we input in a power plant, for both construction and operation, for every kW of electrical output produced – i.e.: plant relative energy utilization efficiency. The higher the number is, the lower the efficiency becomes for power production.

2.3 INDIVIDUAL PLANT ANALYSIS

There are several features particular to each plant that makes it more or less suitable for certain applications, and more or less suitable for environmental reasons. Let's examine them individually:

2.3.1 Hydro power

This is a mature energy that once operational provides electricity with a very reliable, lowest cost, low pollution power plant. Its high capital cost and high pollution, during its construction, is followed by zero cost for fuel and zero pollution over its operating lifetime. It produces electricity very efficiently. All the above make hydroelectric power unquestionably the best option for a public utility.

The only problem is that most potential sites have already been used and there are very few sites left to exploit. Once a site has been identified, a plant will likely be built. Environmental groups instead of opposing it will do better to identify any potential environmental problems, and to pressure their government to provide solutions.

The Utility that operates the plant is passing its costs to the consumers of power, and it realizes significant margins and profits to finance solutions to any properly identified potential problems.

Success to solving any environmental problem depends on the good will of Government and the Utility, as well as the approach taken by environmental groups. It has nothing to do with the technology of the hydroelectric plant itself.

Hydropower is best suited for base, peak and stand-by load operations. As stated earlier, during construction, it consumes a significant amount of oil to run the construction equipment and this gives it some sensitivity to increases in the price of oil. For tar sands based power, this plant is not suitable because it does not produce any waste heat as a by-product of its electricity production. Large quantities of such waste heat are necessary for the production of oil.

2.3.2 Nuclear Power

This is a developing form of energy that has had a bumpy road. Society has developed a nuclear allergy for reasons that, as we will see, have nothing to do with the technology itself. (See below facts and fiction about nuclear power). Its capital costs are compatible to hydropower. It produces electricity very efficiently.

The nuclear fuel is a highly condensed form of energy and its cost is extremely low. A cylindrical shape the diameter of a human finger x ¾ inch long can produce enough power to meet the needs of 100 houses for one year. This low volume of fuel requires a small amount of oil to mine, refine and manufacture, and therefore nuclear fuel is virtually immune to increases in the price of oil.

The costs of radioactive waste management and plant decommissioning are also included in the analysis above on the cost/kWh. As the industry matures these costs should be expected to decline, as newer and improved fuel cycles and types of plant are built. More details are provided in facts and fiction below.

The amount of oil required, for the construction of a nuclear plant, is similar to any large industrial installation or power plant such as coal or oil fired, and this is included in the table above. Note however, that coal and oil fired stations have a higher sensitivity to oil price increases because of the fuel they consume during their operation. Column #2 of the table above depicts the total amount of oil sensitivity that includes capital as well as operating consumption of oil.

On the basis of total Grams of CO2 gas released to the atmosphere per kWh of electricity produ(ced: wind power produces twice as much CO2 as nuclear, biomass 3 times as much, solar and hydro plants 30 times as much, natural gas 36 times, oil 48 times and coal 70 times more than nuclear. That makes nuclear the cleanest form of energy on the basis of gas emission to the environment.

Currently available nuclear plants don't like to have their power fluctuating according to a variable demand. They can be designed to meet variable load demands. Therefore they can be used for any type of load: such as base, peak or variable loads. For an industrial utility in the tar sands, a nuclear plant is particularly suited as it can provide not only electricity but also a phenomenal amount of heat, hot water, low or high temperature steam, and hydrogen through simple electrolysis, or by adding steam and heat to the electrolysis process to improve the production of hydrogen gas from water. Ideally a nuclear plant in the tar sands would operate at peak load continuously. The type of load may vary between electricity production, steam production, or lastly in terms of importance making of hydrogen. In addition, a continuous supply of heat will be available for hydro-transport.

Finally, but not lastly, a nuclear plant due to its extremely low operating cost (not capital cost) can produce part-time superheated steam for the SAGD process (Steam Assisted Gravity Drain) and electricity for heat tracing (heating the pipes with electric heaters) of long, thermally insulated, pipelines. Of course all the above production comes with negligible gas emissions.

2.3.3 Wind Power

The windmills that we have in Alberta produce 2Mwe (2,000 kW) of power when they run at maximum load. In Southern Alberta, they seem to be running about 60% of the time but their capacity factor averages to 35%. During their construction stage, wind mills consume a small amount of oil and an average amount of capital. This is a developing technology, and already there are pilot projects for 5 MWe windmills that may improve on the performance of the current units.

During operation, the wind is free and the cost of maintenance and repair is low. This makes wind power a very desirable form of power production. The only serious problem of wind power is its reliability of power production. Electricity cannot be stored; it has to be produced, as consumers need it. If there is no wind there is no power. This requires a significant percentage of other power plant capability to be standing by, and ready to produce power during windless periods. This makes wind power suitable for base loads, only where there is a significant amount of stand by capability. Alternatively, wind power could be a source for the production of hydrogen, through electrolysis.

Another problem of wind power is that some people don't like the look of a wind mill farm. However, in an increasingly hungry world for energy, they will get to love them, as low pollution and efficient energy production will become more important factors. As of the writing of this paper, the author has not encountered any adverse reports for livestock or crops affected by windmills. This makes this power technology suitable for double use of a farm as a crop or livestock farm and as a wind farm.

Currently, there is a 35,000,000 kW capacity in Europe and 7,000,000 kW in North America. The fast growth of windmill construction in N. America is now above the available manufacturing capacity and this forces a two-year waiting time to source its components. This waiting time is expected to get worse as oil industry, other power technologies and industry as a whole get on an expansion mode.

2.3.4 Biomass Power

A lot of noise has been made lately about biomass products such as biodiesel, and alcohol (ethanol) production. In some places multimillion-dollar investments are discussed, while the Saskatchewan Government is giving tax incentives to farmers to participate. Let's examine it more carefully.

First of all, we know that photosynthesis, the process that captures the sun's energy in plants, is not a very efficient process. The hydrocarbons that we are consuming today are a fossilized, condensed form of energy that has captured the sun's powered photosynthesis over thousands of years. Biomass crops (corn canola etc.) are capturing photosynthesis for only one year at the most.

Second, we know that growing crops requires the use of fertilizers, pesticides and herbicides all of which are produced from hydrocarbons. Then seeding, harvesting and transporting bulk volumes of crops and distilling or processing require the consumption of oil. The best ratio that has been achieved, so far, is the production of two gallons of ethanol, or three gallons of biodiesel from canola, for every one gallon of oil equivalent used.

This means that a serious dependence on hydrocarbons will continue to exist for the production of either biofuel. This also means that we will have a 50% dependence of the price of biofuel to the price increases in oil. Finally, consideration has to be given on the amount of water that is required as input for every litre of biodiesel or methane produced.

What then does this all mean? Biomass is not a hoax. It seems to have some definite benefits to humanity; however, it does not provide a sustainable solution to the increasing energy needs. On the electricity production front, biodiesel will make an excellent stand by and peak load capability. It can stretch the hydrocarbon reserves to three times as long (since 1 gallon oil produces 3 gallons of biodiesel). Its use allows for the reduction of sulphur in diesel fuel, cutting down on a key cause of acid rain. The only disadvantage is that power plant based on biodiesel will have comparable cost/kWh to oil fired stations. On the transportation front, ethanol blend in gasoline of 5% will require in Canada alone production of 1.25 billion liters of ethanol per year, which will conserve about 500 million liters of hydrocarbons oil equivalent per year. That is not a small contribution for an emerging technology. Gasoline blended with ethanol burns cleaner than regular fuel and this should play an important role in smog reduction. Canada has large sections of farmland in the prairies; the farmers are now suffering for markets. What could be better than to start growing agricultural products for energy and on top of that to add few wind mills on the large tracts of farmland. The only adverse effect to this energy form is that developing an infinite market for corn (ethanol) and canola (biodiesel) will create shortages for other grains and the cost of bread worldwide will triple.

At this time there are only designs for power stations based on crop derived biodiesel. As far as the tar sands are concerned a biomass-powered station should be able to produce electricity, heat, and hydrogen through electrolysis. The cost of such an operation however would be similar to an oil fired plant. A biomass-fired power plant would likely be used for peak load uses, and as a stand by station. It cannot take the role of primary energy provider due to limits in available farmland and its dependence on hydrocarbons for its fuel production.

2.3.5 Coal fired power

This power plant represents a mature technology. Right now it is the most predominant type of plant in the world. It is however the heaviest polluter and its costs per kWh are no longer as competitive as it used to be.

It has been a good base load energy provider and it has had some significant improvements that have brought under control the acid rain products. Its high pollution component now is mostly the emissions of environmental warming gases such as CO2.

Ideally, this type of plant either should have its CO2 production sequestered or be discontinued as soon as alternative energy stations become available. Their elimination might take 20 to 30 years. Thereafter the coal industry could concentrate and adapt to using coal for gasification or to produce pure hydrogen. Coal mixed with lime and water can produce hydrogen and CO2. Then the CO2 is combined with minerals that capture CO2 and sequestered in the form of rock. In this manner large quantities of CO2 can be removed from the atmosphere and stored in solid rocks.

This area could have some significant developments. The ultimate decision maker will be the cost/kWh that will permit the production of power without the gas emissions to our environment.

2.3.6 Natural Gas fired plants

Natural gas is the cleanest form of hydrocarbons. A power plant fired with natural gas produces electricity with the highest efficiency of any other power plant. Its capital cost is very low, and the construction time is very short. Its only problem is the cost of gas it consumes. It is no wonder then that it has become the preferred type of power station now in the tar sands even for base load use.

The oil companies due to their proximity can get this commodity at "preferred" rates which correspond to about 25 % of its actual cost. This type of plant however, is so versatile that it would make an ideal power plant for peak loads, during the energy transition period, and as a stand by capability provider thereafter.

The sensitivity of the price of gas seems to follow the price for oil. Consequently, it is expected that the public utilities will have the financial incentive to be switching soon from gas-fired stations to other technologies. The problem will persist whenever the user utility does not pay the full value for this commodity.

Natural gas is too valuable a commodity to be burned for electric power, for the production of heat, or for the stripping of its hydrogen. All these functions can be performed much more efficiently by other means in terms of macro-economics, in terms of conservation of resources, and in terms of energy efficiency.

2.3.7 Oil fired Plant

This is a mature technology. Oil fired plants have served humanity well, and it will continue to serve for several decades as we will be entering the transition period for energy during which they will be slowly changed from base load duties, to peak load duties, to stand by load duties, and finally elimination altogether. This type of plant is versatile enough to meet all these load demands.

Oil fired power plants are very sensitive to the increases in the price of oil. By limiting their duties to stand by they will provide a reliable alternative, which will be able to perform equally well for stand by base loads or for peak loads. These plants are not suitable for the tar sands due to environmental and cost factors.

2.3.8 Solar Power

Solar power is a developing technology, and as such it should be given the opportunity to develop. As it stands right now, this technology is a very inefficient user not only of capital input, but also of energy input. The basic problem of solar power is centered on the fact that photovoltaic conversion of sunlight is energy inefficient (total energy input/output) with today's means.

Today's solar panels produce about 20 Watts per square foot. This means that the experimental solar power station in Leipzig Germany, with its 33,500 solar panels (12 square feet each) could be replaced by only two wind mills like the ones we have in Alberta.

To construct the solar panels, the mining, transportation and processing of materials is required, but then the power it produces is so low the cost/kWh becomes astronomical, even if the sunlight is free and environmentally perfectly clean. To pay back the cost of the panels with energy produced it takes about 32 years assuming sunshine every day, and this does not include the cost of batteries and a system for storing the power produced.

This seems to be the basic reason, why solar power plants do not exist except in experimental cases. But there are some positives to this energy. Small scale power in remote areas, although expensive is very reliable in charging batteries. Also, in cities, where an adequate supply of stand by power capability already exists for cloudy days, the placement of solar panels on top of buildings, instead of roof materials, will not only decrease the electricity bill, but at the same time it will give the industry the opportunity to perhaps develop more efficient solar panels.

2.3.9 Oil Shale

This is included here because of extensive interest in the past. As Savage (1967) notes the term oil-shale is a "promotional term" of organic marlstone. It is a very diluted source of organic material that costs at least 4 times the costs of extracting and processing the tar sands, has 1/6 the energy contained in coal and 1/3 the energy contained in municipal trash. It has yet to prove that it can be recovered with a positive energy input/output ratio.

2.3.10 Energy Conservation

This is included here because a lot of published articles allege that energy conservation alone could solve our energy problem. Energy conservation can delay the day of reckoning, but when a commodity is depleted, you simply cannot conserve what you don't have. That is not to say that we can ignore energy conservation. On the contrary, at this stage of humanity we need to conserve and optimize every type and form of energy until we have completed the switch to a sustainable form of energy, while hopefully, there would still be enough hydrocarbons left to supply industries for making plastics, tires, fertilizers and other industrial products.

2.3.11 Syngas

Syngas is a form of energy that can be used in areas with rich carbon deposits. It is particularly applicable at the tar sands because of the very large quantity of COKE and ASPHALTENE that are produced as by-products of the oil extraction. The bitumen at the tar sands has low hydrogen content. In order to produce crude oil out of it the percentage of hydrogen content must be increased. One process is to extract hydrogen from natural gas and add it to the bitumen to enrich it and produce crude oil. This generates much of the greenhouse gas emissions, and consumes a lot of natural gas. The other process is to remove carbon from the bitumen and thereby increase the percentage of hydrogen in the bitumen until it reaches the proportion of crude oil. This removed carbon accumulates at the site as coke and asphaltene. (The asphaltene is coke with a small percentage of hydrogen).

Both coke and asphaltene contain about 7% sulphur. Oil companies in the tar sands have developed a process to gasify these by-products. Syngas or synthetic gas can then be burned in a power producing turbine. Any CO2 or sulphur produced in this burning is trapped and does not go up the stack. Consequently, these two by-products can be burned in an environmentally acceptable way to produce power and heat.

The cost of burning syngas is higher than what oil companies pay now for natural gas but lower than the actual market price of natural gas. The main problem of producing coke and asphaltene is economic. A significant amount of bitumen that is mined (or removed by SAGD) is not going to the market, and consequently Alberta is not earning royalties that would be payable. It is stored at the sites so that it can be burned later by oil producers as a worthless byproduct. Coke and asphaltene can be converted easily into crude oil by adding hydrogen. Consequently they have high energy value and their consumption should be subject to royalties.

2.4 THE AVAILABLE SUPPLIES OF GAS

The estimates for world reserves vary so much that the information was considered to be unreliable. We therefore concentrated to examine only Alberta. Even this picture raises significant questions.

Just five years ago gas reserves were listed to include:

	126	TCF of known reserves and
	223	TCF of probable reserves
TOTAL	349	TCF of total reserves

Now gas reserves are listed to include:

	40	TCF of known reserves and
	57	TCF of probable reserves
TOTAL	97	TCF of total reserves

Note: TCF stands for Trillion Cubic Feet

This means that all gas reserves in the tar sands are only sufficient to supply the entire world's gas demand for one year. That is 2.7 Trillion Cubic Meters or 92.6 TCF. For how long will natural gas at the tar sands supply our needs, with or without the local consumption of the oil companies?

These numbers are produced by AEUB and as a result the oil companies are now starting to look for alternatives. Unfortunately however they are looking at the coal reserves, the burning of which produces three times the amount of CO_2.

As things stand now there are two ways to take care of the CO_2 emissions. One is to go the hydrocarbon route by introducing a massive CO_2 sequestering system that will prove useful only for the next 100 years or so. The other way is to go to some alternative form of energy that will prove to be sustainable for few thousand years.

2.5 THE AVAILABLE SUPPLIES OF OIL

The table below shows the available oil reserves and production rates of each country in which an oil pool has been identified, as listed by the oil and gas journal and energy information administration for 2004.

Country	**2004 Proven Reserves** millions of barrels	**Production** Millions of barrels/yr	**Depletion Time** Current Consumption
Saudi Arabia	261000	2500	60 to 100 years
Qatar	15000	235	40 to 60 years
Syria	2500	186	8 to 10 years
Iraq	115000	735	100 to 150 years
Iran	125000	125	750 to 1000 years
Kuwait	100000	584	100 to 150 years
UAE	96000	684	90 to 140 years
Algeria	11314	310	25 to 35 years
Nigeria	25000	710	25 to 35 years
Egypt	3700	214	10 to 15 years
Chad	1000	100	5 to 10 years
Congo	1506	93	10 to 15 years
Libya	36000	480	50 to 75 years
Gabon	2500	91	20 to 27 years
Angola	5412	326	10 to 16 years
Australia	3500	227	10 to 15 years
UK	4665	824	3 to 5 years
Norway	10447	1149	7 to 9 years
Denmark	1277	135	7 to 9 years
Azerbaijan	7000	110	45 to 60 years
Kazakhstan	9000	300	20 to 30 years
Russia	60000	2703	15 to 22 years
China	18243	1243	8 to 14 years
India	5371	242	15 to 22 years
Malaysia	3000	281	7 to 10 years
Burundi	1350	69	15 to 20 years
Indonesia	4700	407	8 to 11 years
Brazil	8500	546	10 to 15 years
Argentina	2820	269	7 to 10 years
Venezuela	77800	834	60 to 90 years
Ecuador	4630	143	20 to 30 years

Columbia	1942	211	5 to 9 years
Mexico	15760	1160	10 to 13 years
USA	22677	2092	7 to 10 years
CANADA Conventional	4500	808	4 to 5 years
CANADA strip mining	174000	360 Developing Tar sands	
CANADA SAGD	1600000	0 Developing Tar Sands	
WORLD TOTAL	**1068114**	**21026**	**30 to 50 years**
Excluding tar sands		**doubling at 50 years**	
WORLD TOTAL	**2842114**	**21026**	**80 to 130 years**
Including tar sands		**doubling at 50 years**	

This table shows the strategic importance of the tar sands and explains why oil companies are lining up in northern Alberta with investment and projects for the production of oil. It also could explain the strategy of confrontations in Kuwait, Iraq and Iran, as these three countries alone could provide all the US oil demand for about 30 years.

2.6 CONCLUSIONS ON ENERGY SUPPLY

The first conclusion drawn from the table in 2.5 is that the Alberta Government does not really need to provide significant incentives to the oil companies to entice them to invest in Alberta. The oil companies have run out of potential sites to construct new oil producing fields.

It must be noted that the investment required in establishing a new oil-producing field can be justified if the new field will be producing oil for 30 to 40 years. The table in 2.5 clearly shows that outside of the OPEC world there is hardly a site that meets this requirement, except the tar sands.

The second conclusion drawn from table in 2.5 is that new oil fields outside OPEC and Alberta are not financially feasible. The OPEC oil fields are limiting their production of oil due to physical and political restraints. On the other hand, development of the tar sands is not as fast as needed. This has caused an imbalance in the production/demand ratio that keeps driving the price of oil higher.

The third conclusion drawn relates to the sustainability of natural gas. Under the most optimistic case scenario it looks that within 20 to 30 years it will be the first commodity to be deplete d in Alberta. To approximate this date multiply 1000 cubic feet per barrel times the number of barrels produced at the tar sands.

The fourth conclusion drawn, relates to the statement made in the introduction of this paper that the tar sands provide Alberta with a timely and strategic power to spearhead a change of energy sourcing from a depleting resource, in about 30 to 50 years, to a sustainable form of energy for several centuries. This can be achieved by working with the oil companies, sharing their risk, protecting them from loses, and enticing them to an alternative and sustainable form of optimized energy production. The strength of the tar sands will make the oil companies initially receptive. Then it should not take very much to convince them that a change of energy infrastructure for both electricity production and transportation, instead of resulting in a reduction of oil consumption, it would actually result in an increase in oil consumption to create the new infrastructure. It will take a transition period of about 50 years during which the oil companies will need to keep increasing their oil production to meet the normally increasing demand. In addition they will have to produce some 150 billion barrels to power the change in our energy infrastructure.

Thereafter, the tar sands could be producing enough hydrocarbons to meet the demands for tires, fertilizers, plastics and specialty fuels, all of which in 50 years will exceed 50 % of today's consumption. In addition, the infrastructure that will be existing at the tar sands, in the form of power plants, hydrogen producing plants and pipelines will allow the oil companies to continue their growth using the same assets but in a different way - by producing hydrogen fuel and pumping it S, SE and E to the populated areas.

The more leases granted to oil companies and to foreign countries now, without an over all plan, the more this power is eroded along with the opportunity for humanity to achieve a sustainable energy growth. Instead, the tar sands will only serve to delay the day of reckoning.

At present, the oil companies seem to be heading in the direction of carry on business as usual and when the environmental issue of CO2 becomes too intense, will fall back to using syngas and coal and sequester the CO2 into rocks. This process will achieve the desired level of emissions and thereby will solve the immediate problems. It will not however avert the energy supply problems and crisis that we will experience in about 50 years. We will not have avoided the day of reckoning we will simply have delayed it. In this case oil companies will have wasted precious capital and precious time on short term solutions.

PART 3: POSSIBLE ALTERNATIVE FORMS OF ENERGY PLACED INTO PERSPECTIVE

In sections 1.3 and 2.5 of this paper, was hinted at a lost opportunity, if we fail to use the tar sands as a stepping stone to a sustainable energy infrastructure that will last for several centuries. The type of energy; however, was not identified.

As of the writing of this report there are only two known candidate energy forms that together, can provide humanity with a long term, sustainable energy resource, without inhibiting our growth. These are nuclear power for electricity (advanced power plants) and hydrogen fuel for our transportation needs. This should not be a surprise. As it was shown in section 2.1 some form of nuclear reaction has always been the primary source of our energy needs, regardless of which technology we use. It is therefore necessary to put into perspective these two energy options and examine all their pros and cons.

3.1 HYDROGEN POWER FOR TRANSPORTATION

We all know that the seawater contains a vast amount of hydrogen. The problem is that this hydrogen is combined with oxygen to make the water. To separate the hydrogen from the oxygen takes a lot of energy input. In fact, the energy that is required to separate the hydrogen from the oxygen is slightly more that the energy that we get out of burning the hydrogen itself.

This means that hydrogen is not really a natural fuel. It is a synthetic man made fuel, or energy storage medium much like batteries. We still need a primary energy input, of about 115% input/output ratio, to produce the hydrogen. This energy can come from any power plant that can produce electricity. However, based on previous discussions, it seems much more economical in terms of financial investment, in terms of efficiency in energy use, in terms of conservation of resources, and in terms of environmental considerations (see below facts and fiction), that the bulk of the energy required for the production of hydrogen should come mainly from nuclear power. For the same reasons advanced designs of nuclear plants would form ideal options for base load electricity production. This leaves the field free to wind power to provide base load power or to produce hydrogen, whenever there is wind; to biomass for base and peak electrical loads; to fuel additives for transportation; and finally to gas fired and even oil fired plants to serve as stand by capability for the production of electricity.

Long term production of hydrogen can be achieved by coal fired plants and by nuclear plants. We saw in chapter 2 that the cost/kWh of a coal fired plant is higher than nuclear. If we were to add the costs of the CO2 sequestering process it will become prohibitive even with carbon credits.

At present 95% of North America's hydrogen is produced from natural gas. Through a process called Steam Methane Reformation, high temperature and pressure break the methane and water in the steam , into hydrogen and carbon oxides- including carbon dioxide CO2, which is released to the atmosphere as a greenhouse gas. Another process called Shift Converter uses carbon monoxide CO with hot steam to produce hydrogen and CO2 which is also released to the atmosphere. Pound for pound hydrogen contains almost three times as much energy as natural gas, and when consumed its only emission is pure water. It is therefore very desirable; however, using dirty energy to make clean energy doesn't solve the pollution problem.

Nuclear plants based in the tar sands could provide an abundance of waste heat (to prevent the bitumen from freezing in the winter or to heat the hydro-transport system), an abundance of steam (superheated or saturated for the SAGD processes to cause the deep oil to flow), an abundance of electricity (to power the production process of oil), an abundance of electricity to produce hydrogen for feedstock into the hydro-treatment, and an abundance of hydrogen for the already existing pipelines network capable of transporting hydrogen gas to populated areas in the East, South East, and Southern markets where it can be used for transportation fuel.

Hydrogen can be produced through electrolysis and this process can be enhanced by using hot steam. Furthermore, the recent development made at the General Electric research facility in Niskayuna, NY has reduced the cost of the electrolysis process by 50%. It brought the cost of 1kg of hydrogen (an energy equivalent of roughly a gallon of gas) to $3 instead of the current $7.

Environmentally acceptable hydrogen production technology is improving quickly. The only part missing from this scenario is the retail infrastructure for distribution, and the engine to consume hydrogen gas. The retail distribution is controlled by the oil companies, which should appreciate the incentive to convert themselves into energy companies that supply both hydrocarbons and hydrogen.

The Laurence Livermore Laboratories have already designed and tested a 400 HP turbine engine that operates on hydrogen gas. They have also developed a storage system that prevents the hydrogen from exploding if there was a head on accident between two hydrogen-powered automobiles. Also, Ford Motors on July 17, 2006 completed testing and announced production of an internal combustion V10 engine,designed to burn hydrogen. This is the first automaker in the world to do so, although others have experimented with internal combustion engines burning hydrogen fuel.

Society is working on biofuels, efficient light bulbs, hydrocarbon gasification, sequestering of green house gases and other technologies; however, it is only the use of hydrogen which will ultimately provide the easiest infrastructure pathway to change.

What all this means is that the oil industry is in the vanguard of a marketing opportunity that will not only resolve all their current energy and environmental problems, while increasing the production of oil over the next 50 years, but will also be entering a new energy market, with existing assets, that will not get depleted for several centuries. The only issues to be addressed is the perceived or real risks associated with nuclear plants.

3.2 FACTS AND FICTION ABOUT NUCLEAR PLANTS

In this section the problems associated with nuclear power will be examined, whether actual, alleged, or perceived. Proponents of other forms of energy, and environmentalists have made several complaints against this form of energy. Ultimately, all problems can be summarized by the following points:

a) Nuclear power is very expensive, so expensive that some utilities just about went broke while building nuclear power stations.

b) Nuclear power is unsafe. Reactors can explode like a nuclear bomb.

c) Nuclear power is unsafe. Reactors can explode like a dirty bomb. The heated up core can melt its way through the earth.

d) Nuclear plants produce radioactive wastes that can live for hundreds of thousands of years.

e) Nuclear materials (spent fuel) can be stolen and some one could make a nuclear bomb working in his garage.

f) Reprocessing is a dangerous activity as it can divert fuel to bomb grade material.

g) Nuclear plants can be sabotaged by terrorists

Before addressing each of these fears individually, an introduction would help to place things in perspective. First, it must be appreciated that we first became aware of nuclear technology when it came into our lives as a military weapon – a bomb that devastated Hiroshima. Second, it must also be appreciated that radiation cannot be detected by our normal senses, i.e. by vision, hearing, smelling, tasting, or tactility. Consequently it is perceived, and is, a form of danger undetectable by our own senses. We do need the assistance of trusted experts to insure our safety. As a result, if anything goes wrong in a nuclear plant, regardless of how minor or negligible it is, the fear in the human mind tends to amplify it out of proportion.

Finally, it must be appreciated that products of nuclear reactions are and have been bombarding our planet for thousands of years and that radiation has enhanced and sustained our lives. In summary then, radiation can be beneficial in small doses, damaging in large doses (that is where we need the experts for advise), and detrimental in abusive doses.

As we will see below, The Chernobyl accident was the most serious industrial accident ever. Yet, it still belongs in the category of "a damaging large dose", and not in the detrimental category of a bomb. The author of this paper was in Europe at the time of the accident and could not justify or comprehend the level of panic and the laughable reaction of a population thousands of miles away from ground zero. It took several years of study, contemplation, and analysis – while working in the nuclear industry – to understand the fundamental reasons for such a reaction. At the end, it was concluded that the nuclear industry is its own worst enemy. Since radiation cannot be detected with our own senses, we can only depend on the word and advice of the experts for our safety. This indicates that nuclear experts have to be trusted by the public. That trust should be earned and it should be absolute and unquestionable.

Did the nuclear industry do anything to gain that trust? Absolutely not, but not because there was any malice. Large companies dominate nuclear business, and large companies tend to become bureaucratic. A typical and common characteristic of any bureaucracy is to circle the wagons, whenever a problem comes up, and with some arrogance, take the attitude of "us against the world". They avoid confrontation, evade questions, fudge their answers, and occasionally lie flat out. This is what we call "spin" and this is exactly what the nuclear industry has been doing over the years unnecessarily. In the process, not only did it not gain the trust of any outsider, but also at the end it lost the confidence of the public. Spin is part of the human nature, it is what governments are doing, this is what large companies are doing, and it can be successful as long as you don't have accidents the size of Chernobyl, the Exxon Valdez or Bhopal in India.

Just think of the implications of a reporter visiting a nuclear installation and being told that the plant was "going critical" at any moment. His first reaction would have been to run out of the station, a case of misunderstood terminology. As we will see later in this article, unless a nuclear reaction is assisted, the (thermal) reactor will shutdown. When it goes critical, it means that it can just sustain reaction and not shut down. No expert has explained this to the wide public. As a result one wonders what would this reporter think as he leaves the plant, what is he going to write in his paper the next day, and finally what will his readers think?

The general public has not received a simple comprehensive report of what has happened to Chernobyl since the accident. A summary is being provided for you here, as a test, to compare what you thought has been going on there, with what is actually going on 20, years after the accident. Also are included several examples to show how the mishandling of clear and concise information, primarily by the nuclear industry itself, has resulted in misconception, unreasonable fear, and fictions which have snowballed out of control. The funny thing is that the nuclear industry has done very little to address and correct this situation. Instead they call people ignorant. The general public shouldn't have to study nuclear physics to appreciate the various situations. It needs facts and it needs the truth, both of which will create the trust.

a) Nuclear power is very expensive. So expensive that some utilities just about went broke while they were building nuclear plants.

Based on the economic analysis given in PART 2, with regards to the relative cost/kWh of all the power plants, it becomes obvious that such a statement is not correct. In fact, nuclear power plants today are cheaper than all other plants except hydroelectric plants. However, it is true that Ontario Hydro and some US based utilities in the seventies just about went broke while building nuclear plants. This kind of problem, I can argue, has nothing to do with nuclear power technology. It can happen in any industry that builds multibillion-dollar installations, and the project takes many years to be completed.

When a multibillion-dollar project is committed, the owner starts to pay advance and progress payments to the various contractors. The accountants start calculating and accumulating interest on these payments and they compound it until the project is completed and the installation starts producing cash from its operation. This is called either "interest carry over" or "construction indirect".

For a project that takes 8 to 10 years to complete the "interest carry over" amounts to about 50% of the budgeted amount for the project. Consequently, when you hear that a reactor costs 2 billion dollars, in reality all the payments made, amount to about 1 billion dollars. The rest is interest carry over. Note that during the final stages of such a project the "interest carry over" costs about 2 million dollars per day.

During the late seventies, after the Three Mile Island accident, the authorities started changing their requirements for the nuclear plants, including those under construction. Changes caused the introduction of design modifications and ensuing construction delays. These delays caused the interest carry over to skyrocket. That cost caused the utilities to just about go broke. This had nothing to do with nuclear technology itself.

The same problem applies to any industry. For example, when an oil company budgets 10 billion dollars for a project, that will take 8 years to complete, the actual amount of payments that it makes is only about 5 billion dollars. (roughly $2.5billion for equipment and $2.5 billion for construction). The rest is interest carry over. If the Government changes its requirements after the project has started up, the interest carry over will cause significant financial pain to the oil company. The oil companies are just as vulnerable to changing conditions and requirements, as was the nuclear industry in the seventies. Therefore, it is very important that the Alberta Government initially evaluate thoroughly every new application, so that no changes need to be made after approval has been given.

Based on the above summary, the statement that nuclear power is very expensive is clearly fictional.

b) Nuclear power is unsafe. Nuclear plants can explode like a nuclear bomb.

There are 440 nuclear power stations operating in the world today. 98% of them are the thermal type. All the reactors in Canada are thermal. The physics of the thermal type of reactor are such that a nuclear explosion, simply put, cannot take place, even if all the operators together try to sabotage it. The worst that can be achieved is fire, meltdown of the core, steam explosion, or chemical explosion, but it is definitely not possible to have a nuclear bomb type of explosion which is hundreds of thousand times more powerful, than a dirty bomb. (See below)

We now have evidence that naturally occurring underground nuclear reactors have operated for thousands of years heating water without any need for controls. We have no evidence of explosions or any adverse consequences from their operation. All that it takes is for water to flow through an underground deposit of uranium. For further reading see Physical Review Letters, Vol. 93, No18, Paper 182302; October 29, 2004. Based on evidence obtained, it is not inconceivable that while hot springs are mostly heated by the earth's core, some might be heated by underground nuclear reactions. The earth filters all the contaminants and all that we get at the surface is clean hot water. The basic physics of commercial nuclear reactors are not dissimilar.

Based on the above summary, the statement that nuclear plants can explode like a nuclear bomb is definitely untrue. Their fuel does not have the enrichment levels needed for weapons grade fuel. Their physics tends to shut them down. And finally several back up systems are activated to "TRIP" the reactor and shut it down.

c) Nuclear Reactors are unsafe. They can explode like a dirty bomb. The heated up core can melt its way through the earth's core.

A dirty bomb is a chemical type of explosion, small or large, that spreads into our environment undesirable substances such as arsenic, anthrax, toxic chemicals or radioactive isotopes. Chemical fire and steam explosion can happen in any power plant, oil refinery, or steam producing industrial installation. The difference with a nuclear plant is that a chemical or steam explosion can release radioactive elements, instead of smoke or toxic substances. Therefore, the containment buildings of nuclear plants in North America are designed to contain such explosions.

The TMI (Three Mile Island) accident and the Chernobyl accident both started with an operating error. Both involved a chemical explosion, a steam explosion, a fire and melt down. Both had the ingredients and ability, and did cause a dirty bomb type of explosion. The consequences to the public, however, were totally different in the 2 incidents.

(i) In the TMI occurrence, although the TMI reactor, destroyed itself, and although it ended up containing a lot of radioactive water, nobody died, and no serious amount of radioactivity was released to the environment. Public anxiety and fear were the only consequences for the public. As far as the utility was concerned, thousands of tons of radioactive water had to be purified before releasing it into the Delaware Bay, the reactor design was evaluated by an external team of professionals and the remaining TMI nuclear reactors were restarted and are now operating. Decommissioning of the damaged unit is continuing. The one good thing that came out of this accident has been the verification to the professionals that all the reactor safety systems, including the containment, worked close to its intended design. These systems reduced the accident to a "contained dirty bomb" with no public consequences.

(ii) The Chernobyl station was the graphite core type, an old design that has been discontinued in North America for the last 40 years. This RMBK type of reactor was built by the Soviet Union during the cold war. Its primary purpose was to produce plutonium for weapons, not electrical power. In case of a fire in its core, a lot of graphite could be burning for several days. The Ukraine authorities, as well as the owners and the operators of the Chernobyl station, knew of the weakness of this design. There were letters exchanged, now posted on the Internet, that acknowledged the plant's instability and postulated various accident scenarios. Nobody did anything about it.

It was also known that the graphite core could ignite and it could sustain a fire for about two weeks. It was known that the roof of the reactor was not constructed to contain a steam explosion. Again nobody did anything about it. No boron, which is known to be effective in putting out fires in a nuclear core, was stored at the site.

Once the roof was breached by steam explosion, fire in the graphite core caused a lot of radioactive particles to be lofted into the atmosphere for about 10 days, thereby forming a "dirty bomb out of control". About 30 plant workers died from this accident most of them risking their lives trying to put out the fire. The problem could have stopped there but it didn't.

The authorities knew that the population, down wind from ground zero, should immediately be supplied with iodine pills and then be evacuated from the area. Yet the authorities waited one day before they announced the accident and a week before they gave all people iodine pills and evacuated the contaminated areas. Meanwhile, children were playing in highly radioactive puddles of water, and drinking milk from cows that were grazing on contaminated soil. As a result of all this inactivity 4,000 cases of radiation-induced cancers have been reported and are attributable to the Chernobyl accident. Most of the victims are children.

Following the accident, professionals evaluated the design of the Chernobyl type of reactor and it was decided to shut down the remaining Chernobyl reactors, as the design was judged to be unsafe. Other similar type of plants had to be modified.

In summary, here we have two nuclear plants, TMI a relatively modern design plant and Chernobyl an old generation plant, known to be unsafe. The authorities at TMI were alert and standing by in case of emergency, while the authorities at Chernobyl were an unprepared, and indifferent bureaucracy. The TMI accident released less pollution and toxic substances than a typical fire in an oil refinery, while the Chernobyl accident released enough to be considered the worst industrial accident in human history. The TMI accident had no casualties while the Chernobyl had 30 initial deaths and about 4000 more anticipated deaths due to the accident. The TMI design received permission to continue operating while the Chernobyl was discontinued permanently. Other similar plants were modified and had a containment building constructed.

What all this means is that nuclear power is a developing technology. Every new generation of power plants increases performance and safety. If we had grounded the original airplane of the Wright Brothers for fear that it might fall on our heads, we wouldn't have the efficient airplanes and jets, whose benefits we now are enjoying. It is interesting to note that the damage to the public in Chernobyl was not caused by the nuclear technology itself, but by its misuse, by incompetent Government agencies.

One good thing that came out of the Chernobyl accident was that this was a live experiment to find what happens when the equivalent of a dirty bomb is exploded. This should be of interest to the general public.

Once a steam or chemical explosion takes place from a dirty bomb, or from an old design nuclear plant, a lot of radiation is released to the environment. Fortunately, most radioactive particles are metals and the higher radioactivity is found in the heavier metals. Here it must be appreciated, that in the absence of the power of a nuclear explosion, metals don't float suspended in air for very long, or travel very far. They settle on the ground within a five-mile radius of ground zero. This is always the case except for three radioactive isotopes: Iodine 131, Cesium 137 and Strontium 90. None of them is dangerous in small amounts outside the skin of the human body, but any one of them is very dangerous if ingested. They are light and are propelled by the prevailing wind, at the time of the accident. Hence nearby populations should be alerted immediately, especially in the downwind direction.

The Iodine dissolves in water and when inside our bodies it tends to concentrate around the thyroid gland that is sensitive to radiation. Therefore, non-radioactive Iodine tablets are taken immediately to saturate the area around the thyroid and hence keep away the radioactive isotope. After about one week the radioactivity level of the Iodine isotope decays to safe level and this danger is over.

The Cesium and Strontium isotopes fall from the air like a dust and contaminate the downwind area. Their radioactivity is decreasing continuously but it takes about 40 years to reach a safe level. During this time all vegetables and fruit should be washed thoroughly if harvested from contaminated areas. All porous berries, all dairy products from grazing animals, all meat products should not be taken from downwind farms. They should be imported from the upwind areas.

Ronal Chester of the Texas Technical University and Brenda Rodgers of West Texas A&M University took measurements in 2004 around the accident site at Chernobyl. They found the following amounts of radiation around Pripyat, a town of 50,000 stretching between two and four miles from ground zero.

Outside the plant at ground zero the radiation was:	4.4 Millirem/hr
Three quarters of a mile away from ground zero:	9.3 Millirem/hr
At the start of the town of Pripyat : (Two miles away from ground zero)	2.8 Millirem/hr
At the other end of Pripyat : (four miles away from ground zero)	0.1 Milirem/hr

A member of the general public is permitted to get 3,000 Millirem per year. This means such a person can stand safely:

-outside a building at ground zero - about 28 days per year continuously.

-¾ mile away from ground zero - about 13 days continuously *

-2 miles away from ground zero - about 44 days continuously and

-4 miles away from ground zero - indefinitely,

**This is how far the force of the fire pushed the heavy radioactive metal particles.*

The above numbers are conservative. For example a radiation worker is allowed to absorb almost double that amount of radiation per year. Just to place it into perspective, one chest x-ray is 60 to 100 millirem of radiation. Also, older people will remember the x-ray machines at the shoe stores in the fifties that gave out 300 to 500 millirem. The readings of Chester and Rodgers also appear low now that we are 20 years after the accident. At the beginning, after the accident, they were much higher.

Early estimates that hundreds of thousands of people would die from Chernobyl have been proven wrong. The land, outside the five-mile radius from ground zero, is now cultivated, and 400 people have been living back in their homes in Pripyat for the last 18 years, (within the five mile radius). Some are raising chickens. Regular blood tests show them to be healthy. Wild life has reclaimed the hundreds of square miles of abandoned land in the exclusion zone. It is reported that wolves, storks, eagles and a rare breed of horses are thriving in the marshes. Over all, ecologists marvel at how resilient nature has proved to be in the face of radiological adversity.

I was reading a new (2005) atlas and in the pages dealing with events in human history, I noticed that there was nothing mentioned about the end of American revolution or the end of WW2, but in 1976 it was stated: “1976 the Chernobyl reactor exploded in Ukraine devastating thousands of square miles and spreading radiation across Europe”. Which events have altered human history more?

Can nuclear reactors be exploded like a dirty bomb? The answer is yes but more likely the explosion will be contained like the TMI in the containment building. Can the core melt its way through the earth? The answer is no. At some point heat stops been produced and the melted core cools off.

d) Nuclear plants produce radioactive wastes that can live for hundred thousand years

Nuclear plants, like any other industrial plant, produce a lot of garbage. Some of this garbage is radioactive. This means that some waste gases, some waste liquids and some waste solids contain particles that emit radiation. All solid, liquid and gas wastes are tested and catalogued for their radiation content before processing.

The radioactive gases and liquids have their radioactive particles removed, by various methods, or the radioactivity is reduced before they are tested again and released to the environment. This leaves behind only radioactive solids.

The solid wastes fall into four categories:

(i) Non-radioactive: This is processed as common industrial garbage. There are monitoring stations through which this garbage must pass. If radiation is detected alarm sounds and the passage is denied.

(ii) Low radioactivity: This includes staff coveralls, rags, and other materials that will remain radioactive for a period of five years or less. They are packaged and buried in controlled burial sites that will be released to the environment in five years. Again checking takes place before release is approved.

(iii) Medium level radioactivity: This includes filter cartridges, rags, resins and discarded parts that will remain radioactive for a period of 5 to 50 years. They are packaged and buried in controlled burial sites that will be released to the environment in 50 years. Here again a checking is required before release is approved.

(iv) High level radioactivity: This includes structural materials of the reactor core, which stay radioactive for about 100 years, and spent fuel that stays radioactive for 10,000 years. These are currently packaged and stored at the reactor site while awaiting approval for burial in deep underground burial facilities.

This is the state of the technology right now. However I am thankful that the industry has not yet received approval to bury the spent fuel. This is my second major personal disagreement with the prevailing consensus within the nuclear industry. When the spent fuel is removed out of the reactor, only 1% to 5% of the fuel has been used depending on enrichment level. 99% to 95% is considered to be a waste to be buried. Imagine getting a barrel of oil, burning a teaspoon of it, and then burying the rest for 10,000 years.

Spent fuel can be recycled and it can be put into another reactor type and be burned, recycled, and burned again until almost 99% of it is burned. With this method there is almost nothing left to live for 10,000 years. The industry has been too complacent wanting to use only fresh fuel, the easy way. Without the recycling of its spent fuel, nuclear power is not a sustainable energy because we are burning only a small fraction of the fuel resource. This will cause our known uranium resources to last only about 150 years instead of 3,000 and create a large amount of radioactive waste that will live for 10,000 years.

So to address the allegation, that nuclear plants produce a lot of radioactive wastes that live for hundred thousand years. The answer is no they don’t have wastes that live for 100,000 years. Right now they have some waste (the spent fuel) that could live for 10,000 years. This waste however, makes an excellent fuel for the next generation of reactors, which, if public attitudes permit, will be reprocessed and burned. This will eliminate this longevity of waste problem, by reducing the volume and maximum lifetime of almost all the radioactive wastes to about 200 years.

e) Nuclear materials (spent fuel) can be stolen and some one can make a nuclear bomb working in his garage.

As described in the next allegation (f), the spent fuel contains less than 5% plutonium. In order to convert it to 99.9% and produce weapons grade plutonium, the thief will have to have an enrichment facility. This means that he will have to disassemble the fuel assemblies, heat it to the point that the metal becomes gas, centrifuge the hot gas to separate and hence enrich the plutonium to nearly pure state, alternatively he will have to dissolve the alloy chemically and separate it, then cast certain shapes out of it, machine it and then assemble the bomb.

All these might sound possible until one realizes that spent fuel is radioactive enough itself to be defined as“ self protected” for a few hundred years against most groups wanting to obtain plutonium 239 for building nuclear weapons.

The thief will need a $50 to $100 million facility in his garage, will need to steal two truck loads of spent fuel, and will have to find a way to transport the stolen spent fuel without being detected by thousands of detectors that exist around nuclear plants, cities, border crossings and in satellites.

On August 17, 2006, a Vancouver B.C. newspaper reported that a Surrey man triggered radiation alarms while he was traveling in his car. He found himself surrounded by heavily armed security. After half an hour of questioning it was determined that the suspect had had an injection of a mild radioactive dye, as part of a diagnostic medical procedure. The question then is: if this man triggered alarms based on a small dose of radiation, what will happen when two truckloads of highly radioactive spent fuel with plutonium start traveling?

Based on all the above it is safe to say that an individual cannot make a nuclear bomb in his garage from stolen spent fuel.

f) Reprocessing (enrichment) is a dangerous activity as it can divert fuel to make nuclear bombs

Nuclear materials can be divided into two kinds, stable isotopes (which do not decay and hence do not emit radiation), and unstable isotopes (which do decay and hence emit radiation).

Natural Uranium as it is mined from the ground and refined, contains 99.28% U238, a stable uranium isotope, and 0.72% U235, an unstable uranium isotope.

When the unstable U235 decays it shoots a neutron into the stable U238 and converts it into unstable plutonium. This is U238 + 1 neutron = U239 (which is plutonium). As U235 decays further it shouts a second neutron into the unstable plutonium and breaks it into two parts, loose neutrons and heat. This is U239 + 1 neutron = 2 fragments + loose neutrons + heat, this is called nuclear fission.

There are 2 types of reactors, the ones that burn natural uranium, the composition of which is given above, and the ones that burn Enriched Uranium. The enrichment process removes stable U238 and increases (enriches) the percentage of the unstable U235. The average “fuel enrichment is 4.5% and wastes a lot of U238 which is called “depleted uranium”.

When the fuel is removed from the reactor and classified as “spent fuel” only 1% to 5% has been used. The remaining 95% is wasted. This holds true whether the original fuel was Natural Uranium or Enriched Uranium. In the Canadian reactor we burn Natural Uranium i.e. 99.28% U238 + 0.72% U235. When the fuel is classified as “spent” and removed from the reactor it contains: 98.58% U238, 0.27% U239 and only 0.23% U235. The end result is similar for plants using enriched uranium, but with more plutonium U239 depending on the enrichment level of the particular fuel rod.

In the previous section e) it was explained why an individual cannot make a nuclear bomb in his garage. But what are the difficulties to a country that has the financial resources. Can they make a bomb? To make a plutonium bomb one needs more than four kilograms of pure plutonium U239. In the spent fuel its maximum concentration is less than 5%. A purity of 99.9% is needed. The only way to achieve this weapons grade purity, is by enriching it with the centrifuge or chemical process described in the previous section e), Yes, if a country has the resources it could do it, but (as usual), there are some problems to overcome. For example, a centrifuge can produce only 1 - 2 grams of pure plutonium per year. This means that the country will need to run continuously, for 1 year, at least 2,000 centrifuges to make one bomb. With proper inspection surveillance this could never happen. For chemical enrichment, all the specialized complex chemicals are monitored substances.

To make an enriched uranium (U235) bomb, it is slightly easier because it does not need to use spent fuel, but while one needs lower enrichment purity, than with plutonium, one will need a much larger volume of U235, about four times.

Japan is now building a large enrichment & reprocessing facility. Right in the middle it has set up a five star hotel, and invites any international inspection at any time. If Iran were to do the same thing it would get credibility with regard to its nuclear plans. The same should apply to any country that has aspirations to proceed with nuclear power. Reprocessing is an integral part of nuclear power.

To summarize on this allegation. Can a country divert fuel to make a bomb secretly? The answer is a qualified Yes. A country that remains open for international inspection, would find it very difficult but not impossible to hide high enrichment levels of uranium or Plutonium to weapons grade. The key qualification is “as things stand right now”. Remember that since nuclear is a developing technology, several new developments have taken place to eliminate problem areas. As example I will list three developments here.

a) In February 2006 Global Nuclear Energy Partnership was established with a plan to form an international partnership to reprocess spent fuel in a way that renders Plutonium in it usable for nuclear fuel but not for nuclear weapons.

b) Generation IV, reactors now on the drawing board, produce a spent fuel that is heavily spiked. This spiking does not prevent the fuel from being suitable for reactors but it makes it very hard to manipulate chemically, steal it or make nuclear weapons.

c) Generation IV reactors are intended to reprocess their spent fuel at the reactor site with a method called "pyrometallurgy" This is also the type of reactor that burns all its fuel, leaving behind minimal amount of wastes.

The wastes from this spent fuel are expected to live for only 200 years and are lacking the unstable isotopes that would make them useful for the making of weapons.

g) Nuclear plants can be sabotaged by terrorists

Terrorists can sabotage any industrial plant. Nuclear plants, because of their extensive array of safety systems will cause less impact to the public than could sabotage to oil refineries, chemical plants, or conventional power plants.

The worst that can be done to a nuclear plant was done at TMI, which was to create a dirty bomb. The plants safety systems controlled it, and there were no consequences to the public.

To address this final question, yes terrorists can sabotage a nuclear plant. It is suggested that the public should hope that if some terrorists decide to attack, they will chose a nuclear plant instead of chlorine or an ammonia production plant.

To summarize, we started this part of the paper by stating that at low levels radiation has been beneficial, while at high levels it is damaging. There is no expert that knows for sure, the level at which radiation stops been beneficial and it starts becoming damaging. Therefore, it is better to err in the safe direction. People should minimize their exposure whenever they have a choice. Medical diagnostics and especially dental diagnostics (close to the thyroid), account for most of the radiation received by the public above background level.

PART 4: CO2 AND THE WARMING TREND

4.1 INTRODUCTION

Some scientists claim that our atmosphere is warming. Others doubt that this is true. There is also a debate on the answer to the question: that if a warming is taking place, why it is happening. This will ultimately define the where, how and when this warming trend will stop, and what will be the consequences.

On the one side of the debate, we have environmentally sensitive groups that suggest that an increasing amount of production of CO_2, since the dawn of industrial revolution, is accumulating in our atmosphere, and is trapping heat, and thereby causes the warming trend.

On the other side we have industries consuming fossil fuels (hydrocarbons and coal), which suggest that the claims made by the environmentally sensitive groups are not proven, have no scientific foundations and consequently are not true. As a result, they don't accept them and continue to release CO_2 to our atmosphere.

Do we have an over-exaggeration from the first group or do we have an over-simplification from the second. This is what part 4 will try to answer by examining the facts for both sides. Mathematical models and theoretical results have been avoided. Instead, consideration has been given only to undisputable experimental data based on facts. In this manner some conclusions are drawn.

Paleoclimatology is the profession that analyzes the climate on the earth over hundreds of thousands years based on the examination of : tree rings, marine and lake sediments, pollen, ice cores, boreholes, glaciers etc. The intent of all these methods is to determine the timing, the temperature, and the composition of the samples at the time of their formation. This allows researchers to derive historical records of the timing of warming and cooling trends, as well as the timing of the percent composition variations of CO_2 in the atmosphere.

4.2 HISTORIC CO2 CONCENTRATION

The first evidence that we have is from work done on accumulating data for CO_2 concentrations in the earth's atmosphere over the last 600,000 years. (see: Etheridge et Al Commonwealth Scientific & Industrial Research Organization-Australia, C.D Keeling Scripps Institution of Oceanography, and Tom Wigley National Center for Atmospheric Research). This data shows that the historic concentration of CO_2 in the earth's atmosphere has been varying with 100,000-year cycles. It peaks at 275 parts per million (ppm). In between those peaks it decreases gradually while it fluctuates between 225ppm and 200 ppm and reaches a minimum of 200 ppm about 90,000 years after the maximum peak. During the remaining 10,000 years of the cycle it rises again to a steep peak of 275ppm.

The cycle of the last 100,000 years shows exactly the same pattern as the past cycles except, that during the last 50 years it shows a steep rise from 275 to 378 ppm. This is happening for the first time in 600,000 years of recorded history regarding the concentrations of CO_2 in earth's atmosphere, and it represents a 36% unpredictable increase.

4.3 HISTORIC TEMPERATURE OF ATMOSPHERE

The second evidence that we have is from work done on accumulating data for the earth's temperature fluctuations over the last 600,000 years.

(see: Temperature data by Mann and Jones Geophysical Research Letters Vol. 30 No 15, and Vostock ice-core data Petit et Al- Nature June 3,1999). This data shows that historic variations of temperature in the earth's atmosphere have also been varying with 100,000-year cycles. Its peaks coincide with the peaks in the CO_2 concentration. After the peaks, the temperature fluctuates within 20 degrees F and, similarly to the CO_2 concentration, gradually drops to a minimum temperature at about 90,000 years after the maximum peak. During the remaining 10,000 years of the cycle, it rises again to a steep peak. The temperature variation curves are identical and coincide with the CO_2 concentration curves.

The cycle for the last 100,000 years shows exactly the same temperature pattern of the past cycles. It does not show an extra rise of the earth's temperature by 36%, as in the CO_2 concentration curve. It stays close to its traditional values.

4.4 ASTRONOMICAL DATA ON EARTH'S ORBIT VARIATIONS

The third applicable information that we have (see Astronomical cycles. James Zachos-University of California & André Bérger-Université Catholique de Louvain-Belgium, and Vostok Ice-core data Petit et Al Nature3/6/99, and Pollen-ChristyBriles University of Oregon) suggests a link between variations in earth's surface temperature and cyclical variations in earth's orbit.

One variation with a 100,000-year cycle is related to the shape of the earth's orbit around the sun. It changes from more elliptical to more circular and then back to more elliptical. When it is more elliptical the earth spends more time closer to the sun than away from it, and this seems to cause a rise in temperature and melting of the glaciers. When the orbit becomes more circular the earth spends more time further away from the sun and this seems to cause a drop in temperature and the formation of glaciers. At present the earth's orbit is at the most elliptical position , which corresponds to warmest surface temperatures. This matches precisely the temperature variation predicted by the graph in part 4.3.

There are other variations in the earth's orbit, which can be superimposed and they seem to define the temperature fluctuations during the periods between the warm peaks of the 100,000-year cycles. These variations are based on the changes in the angle of tilt on the earth's axis of rotation, and the circular nature of wobble of the axis. These cycles seem to affect differences between northern and southern hemispheres and have intervals of 19 thousand, 23 thousand and 41 thousand years.

4.5 DATA INTERPRETATION

4.5.1 Surface temperature/ CO2 concentration relationship

Here we observe two historical graphs (one for CO2 concentration (see 4.1) and one for the earth's surface temperature see (4.2)) based on data derived by two independent research groups. These two graphs seem to match every peak and every trough over a period of 600,000 years, except for the last 50 years. It is reasonable then to conclude that there must be a definite relationship between the temperature of the earth's surface and the concentration of CO2. This alone; however, does not tell us whether the temperature variations cause the CO2 concentration to vary, or if the variation in CO2 concentration causes the surface temperature to change.

4.5.2 Earth's orbit/ Earth's surface temperature relationship

Here we also have a natural cause and effect that Physics tell us should be normal and predictable. In fact the earth's orbit and its average distance from the sun predict it. It is also confirmed by the graph of the earth's historical temperature data and in particular by the increased temperatures of about 1 deg F that we are now experiencing. It is reasonable therefore to conclude that the earth's orbital variations around the sun cause the major temperature variations between warming (interglacial) and cooling (glacial) of the earth's surface.

4.5.3 Mechanism through which surface temperature affects CO2 concentration

Taro Takahashi of the Lamont-Doherty Earth Observatory-Columbia University has reported that CO2 is dissolved faster and easier in colder water. He has demonstrated that the warmer the water becomes the less soluble becomes the CO2 in it. This seems to explain the mechanism that causes the atmosphere's CO2 concentration to increase during periods of warming and to decrease during periods of cooling.

An opposing mechanism seems to be taking place with the forests. During warm periods the trees are growing faster and their leaves stay longer on the trees, both of which absorb CO2. This seems to decrease the atmosphere's CO2 concentration during periods of warming and increase during periods of cooling, when the leaves fall and decay. (producing CO2).

It has been estimated that the atmosphere interacts with both the land and the sea, through a variety of mechanisms that exchange carbon. The exchange between the atmosphere, the land, and the sea exceeds 150-200 billion tons of carbon per year. A much larger percentage of this carbon is exchanged between the atmosphere and the oceans than between the atmosphere and the forests. As a result the earth's CO2 concentration is dominated by the temperature variations of the oceans.

4.4.4 Effects on CO2 concentration by human activities

Human activities dump 6.5 billion tons of carbon per year in the atmosphere. This extra load to the atmosphere represents less than 3% of the total amount of CO2 that the atmosphere exchanges with the land and the sea in any given year.

At first such a small percentage would not appear to be serious. After all the estimates of exchanged volumes of CO2 between atmosphere and land or atmosphere and sea would be expected to have a 5% error.

To conclude:

(i) Do we have now a peaking in the CO2 concentration in our atmosphere? Yes we do, as it is shown in the graphs for historical CO2 concentrations over 600,000 years. This peak is 35% higher than normal.

(ii) Do we have a warming trend right now? Yes we do have a warming trend more likely based on the orbital position of the earth and its proximity to the sun.

(iii) Is humanity responsible for the CO2 jump during the last 50 years? Yes, since there has never been a peak like the present one, and since industrialization has caused the excess CO2 emissions, humanity is the likely cause of the excess CO2 concentration.

(iv) Does the excess CO2 in our atmosphere cause extra warming of the earth over and above the cyclical variations of 100,000 years? In other words has green house heating started yet? The answer for now is NO. 600,000 years of data has shown that a change of 5 ppm in the CO2 concentration has corresponded to a temperature change of 1 deg F. Since we currently have an increase of 100 ppm of CO2 concentration, one would expect surface temperature to have increased by about 20 deg. F. This has not happened yet. Since 1900 the average temperature of the earth's surface has risen by only 1 deg. F which indicates that we may not have a problem at the moment. The Green House effect has most likely not kicked in yet. Nobody can guarantee that we will not have any problems in the future, due to increased CO2 in our atmosphere.

Another supporting factor of this supposition is that the green house heating is an uncontrollable process that has a positive feed back. This means that once it starts, a slight warming due to green house gases will warm the oceans and cause more CO_2 to remain in the atmosphere. This will cause more green house warming which will further cause the oceans to absorb less carbon and hence increase the CO_2 in our atmosphere by a much larger amount than the 6.5 billion tones that humanity emits. This will result in further warming and a huge amount of CO_2 remaining in the atmosphere….. and so on. The cycle will continue increasing the amount of greenhouse gases until the earth heats up to the point that we roast like turkeys. This is the characteristic of an uncontrollable process with positive feed back.

A search was conducted to identify any other process that could prevent the green house warming from spiraling out of control. Two processes were found significant enough to have an effect. One was the CO_2 exchange of the forests, as described above. Ever increased heating, however, will kill vegetation resulting in an increased amount of CO_2 released to the atmosphere due to the decaying of plants. The other significant process found is the water cycle, but this seems to reinforce the problem because it is another enhancing process with positive feed back. Water evaporates from the oceans and stays suspended in a warm atmosphere. Water droplets act like a greenhouse gas causing further warming which will cause more water to evaporate saturating the atmosphere at higher elevations. This cycle will continue increasing the amount of greenhouse gases until complete saturation of the atmosphere takes place.

The conclusion of this analysis is that greenhouse warming will start at some point when the level of CO_2 concentration starts a positive feed back. When this point is reached nobody knows. I believe that when that point of no return is crossed superheating will take place within a few years, not decades. For now the above argument should persuade us that we have not caused the warming trend that we are now experiencing. However every effort should be made before our climate takes an irreversible momentum.

The uncertainty rises when we consider that at this stage of the earth's orbit we are near the maximum peak of the 100,000-year cycle for both earth warming and CO_2 concentration in our atmosphere. Any error in our guestimates could have very serious consequences. It is conceivable that we might be approaching the point of no return.

Both sides of the CO_2 and earth warming argument seem to be wrong in over exaggerating or over simplifying the issue. The only way that we can find out the truth is by a full size full-scale uncontrollable experiment. Any adverse consequences will likely be severe and non-reversible. Do we really want to find out if we don't have to do it?

Since no one knows the answer to the atmospheric warming question, it would be prudent to err on the safe side, especially since we have an option that we can adopt right now. Strangely, this option is made available to us by the fossil fuels of the tar sands. Let us use them to change our energy infrastructure now.

PART 5: THE INCENTIVES OF THE STAKEHOLDERS

In the introduction of this paper it was stated that "the interests of all stakeholders in the development of the tar sands, for energy production, can be made to coincide". This is achieved by analyzing and identifying the short term and the long term incentives for each group and by trying to accommodate them.

Before explaining the proposed model, lets identify all the stakeholders, analyze their needs and examine the incentives that will be needed to secure their cooperation for the success of an orderly exploitation of the tar sands initially, and for the sustainable production of energy for many centuries.

5.1 THE NORTH AMERICAN SOCIETY AS A WHOLE

Society's needs, both short term and long term, are the availability of a continuously stable production of energy to meet a continuously increasing demand for electricity and transportation. The cost of this energy should be ideally stable and predictable. Society's long term needs also include a continuous availability of hydrocarbons for the plastics, tires, fertilizers, and other industrial uses. Ideally the processes for the production for both, (our energy and our industrial products), should be sustainable for a long time and should not be in conflict with our environment and our safety.

5.2 THE ALBERTANS

The majority of the people in Alberta want the prosperity of energy production to continue indefinitely. They don't want to end up with an environmental problem, or to interrupt this prosperity with a bust. Ideally, they want to get the maximum benefit out of the exploitation of our Provincial resource in the form of job opportunities, lower taxes, high Government services, etc. The occasional prosperity cheque, is welcome; however, most Albertans would prefer, excess revenue to be invested in some plan that could make this prosperity last for several centuries.

5.3 THE GOVERNMENT OF ALBERTA

In a democratic society, the role of the Government is to serve the people that it represents. Ideally, a Government is looking ahead and proactively takes actions and creates the infrastructure and conditions that will bring future benefits to the people. It becomes a partner with the industry, instead of an adversary, and creates the environment for growth and prosperity. This however, should not be interpreted to mean that the Government should contribute to any industry or subsidize them to maximize their bottom line.

The Government stays in power by earning the love or respect of the people it represents, by maintaining transparency in its transactions with the private sector, and by explaining the policies, and principles that guide its decisions.

Specifically with the tar sands development, the Government needs a continuous, orderly development that maximizes the financial benefit of the provincial resources for the people of Alberta. To achieve this it needs an overall plan and it needs to oversee ensuing conflicts. Intervening to interrupt a "business as usual" approach when some conflict occurs that could lead to serious problems.

5.4 THE NORTHERN ALBERTA COMMUNITIES

The communities in northern Alberta need to grow at a controllable rate in order to be able to provide residential infrastructure and services to their towns. They need to be able to plan ahead and invest for their growth. Before a new worker pays any taxes, the town needs to have in place housing, roads, and utilities. This requires the need for advance planning and investment, to increase the quality of life that in turn, will reduce wage increases intended for a hardship environment.

In the absence of such planning, shortages, inflation and reduction in quality of life will result, all of which hinder the development projects at the tar sands and the well being of the oil companies.

5.5 THE OIL COMPANIES

As stated earlier, the oil companies are tools of our economy. Their purpose is to produce fuel and sell it in order to make money for their shareholders. Like any other investor, they need to control the expansion of their fuel production and to invest only in assets that can operate long enough to pay back the capital costs and to produce profits in line with the risk they have taken. They need stability and reliability of supplies because they are risking a lot of capital in installations. As long as their oil fields and refineries are producing they are happy. Their problems start when the known oil reserves are reduced, or when they operate in areas of political instability.

In part 2.4 of this report, it was shown that both of these problems are occurring right now outside of the tar sands. Most oil reserves are reduced close to the point of "depletion in 30 years" and the remaining reserves are concentrated in politically unstable regions. Since the price/barrel of oil is high enough to make the exploitation of the tar sands profitable, and since the tar sands contain enough oil to keep their assets producing for some 100 years, it is natural then that the oil companies will concentrate in Alberta. Any extra incentives are (probably?) not necessary.

The oil industry's goal is not to solve the world's problems. Although they have highly capable technical staff, their expertise is focused towards the hydrocarbon processes, the same way that NASA is focusing on space projects. All the solutions that they can provide will come through hydrocarbons. They are very conservative and they concentrate on what they know best. Drilling in new and even risky areas for more hydrocarbons seems easier that introducing a new concept of energy.

What good is it to have an exclusive hydrocarbon company when hydrocarbons are becoming a depleted resource?

(i) Obviously, big oil companies will need to develop a non hydrocarbon based fuel, if they want to continue existing and growing after the end of this century, when as shown in part 2.4 it will become uneconomical to invest further in hydrocarbon development.

(ii) In part 1.2 it was shown that even after they develop a new type of fuel, oil companies will still need to produce hydrocarbons indefinitely at about one half of today's production, for plastics, fertilizers and other industrial products.

(iii) Also in part 1.3 it was shown that it will take about 50 years, during which, an enormous increase in the consumption of oil will take place (estimated at 150 billion barrels of oil equivalent) in order to change our dependence from hydrocarbons to another form of energy. It will take a lot of energy to change our energy infrastructure. One could say that "it will take all the remaining hydrocarbons to wean humanity from hydrocarbons".

Oil companies need to begin viewing themselves as energy producers and providers. And they need to start changing their focus. It will take a lot of convincing to realize change in conservative organizations of this size. They will be reluctant to take a big risk and to finance something about which they know very little. They need the Government of Alberta to cushion them from the risks until they learn to appreciate the new technology, and to acquire the knowledge and the ownership at their own pace and comfort.

Several studies have shown that nuclear power fits like a glove in the development of the tar sands. Yet, the oil companies continue to ignore this, and with a business as usual approach, they squander a large volume of gas, and keep increasing CO_2 releases to the atmosphere. Big oil executives should be convinced that "There is an alternative to squandering gas", and there is an alternative form of energy which they can exploit for their shareholders. After a nuclear power plant proves that it can meet all their needs in the development of the tar sands, then economics alone will cause oil producers to become convinced and change their ways.

The oil companies need either the Government of Alberta, or an independent, Tar Sands Utility to take over the risks of a nuclear plant to provide them with the power, heat and steam that they need. The oil companies can always purchase these cash producing assets later once they start looking attractive.

Finally but not lastly, the oil companies must realize early on, that it is in their interest to wean society from hydrocarbons, in a controlled way. This way they would:

(i) Have to increase production of oil (and profits) by 14% per year over the next 50 years to change our energy infrastructure.

(ii) Thereafter will still have a demand for 50% of the current production of hydrocarbons for non fuel products

(iii) They will secure a new market for their products by selling the hydrogen they produce

(iv) They can achieve all this with almost the same assets they have now.

(v) They will be able to compete against an emerging hydrogen industry. (see websites on Hydrogenics and Stuart Energy)

5.6 THE PIPELINE INDUSTRY

The purpose of the pipeline industry is to pump oil and gas from producers to consumers. They have an extensive investment and all they need is supplies to put through. They would be just as happy to pump oil, natural gas or hydrogen gas if an energy change takes place. Hydrogen fuel will involve a small increase in capital costs but this will also involve longer duration for the operation of its assets, which translates to more profits.

A change to alternative forms of energy would be welcome, as this will increase the amount of hydrocarbons to be transported over the next 50 years, and then the same assets (with a liner) can be used to transport the hydrogen.

5.7 THE NUCLEAR INDUSTRY

The nuclear industry right now needs to sell nuclear plants. At least that is what the short-term thinkers believe. Bruce Power has started the licensing process to build a new nuclear power station. What the nuclear industry needs badly is a kick that will throw them off their couch of lethargy and start producing again at high rate. That is, a deal that will have to include a long term growth plan which in turn, will pressure them to complete the development of efficient fuel cycles that will solve the problems of the spent fuel wastes. It should also pressure them to acquire new staff and to establish training programs. It takes a very long time in this business, to train people and to increase capacity. Some of their staff will need to find their way to the tar sands, to operate the power stations. Alberta Universities should take a note of this.

The world seems to think that they can continue business as usual, and if all else fails then they can turn to nuclear industry, at the last minute, with expectations that the industry will perform. This is not the case. You cannot make a sick horse win the Triple Crown. First you must restore its health, and then you must nourish it and train it before you crack the whip. Only then do you have a chance to win the race. The great value of the tar sands is that they can nourish and train humanity's wining horse.

5.8 THE WIND MILLS INDUSTRY

The windmill industry need acceptance as a valid alternative source of power. If built in shallow water they can produce hydrogen whenever there is wind and unlike electricity be stored and be ready to supply the transportation markets. Electricity can be produced as required and when there is less need hydrogen production can take up the slack as long as there is wind.

The industry needs to continue the development of more efficient stations and to resolve the issue of delays during the manufacturing process of its components.

5.9 THE BIOMASS INDUSTRY

The Biomass industry seems to be getting what it needs. The Federal Government has established the requirement for a 5% ethanol additive to gasoline and the production of crops for fuel is getting under way.

What the industry needs now is to further develop and optimize its processes for power plants, and to take part in the change to alternative energy programs. The focusing should be towards plants with the flexible power production for peak loads, and towards fast starting plants for stand by duty. This area will have an increasing demand, as the existing oil fired stations and then the Natural Gas fired stations will be decommissioned due to old age.

5.10 THE COAL INDUSTRY

The coal industry may decline as an electrical power source, unless they develop an economically viable CO_2 sequestering process. However the game is not over for this industry. For the short term, using the process of mixing coal with lime and water, it can be producing hydrogen, while capturing the CO_2 in minerals. For the long term, mixing hydrogen with coal can produce synthetic hydrocarbons for a very long time for the production of plastics, fertilizers etc.

5.11 THE SOLAR POWER INDUSTRY

The solar power industry needs to establish some long term industrial applications by producing roof finishing materials that can act as solar panels for buildings and housing. This can be used in a mass, non-specialty, market to secure some revenues. The long-term goal of this industry is to develop solar panels that capture the photovoltaic conversion with a much higher efficiency. If they cannot succeed, then this form of power will be delegated to only special applications in remote areas.

5.12 THE TRANSPORTATION INDUSTRY

The transportation industry can assist in this change of technology for our energy dependence, by developing (like Ford did) more hydrogen powered internal combustions engines, and using them in some production cars. This demand, it is believed, will create a growing retail market for hydrogen fuel. The production of hydrogen-powered cars will have to increase in line with the ability of the oil companies or their competitors to increase their production of hydrogen.

5.13 THE ENVIRONMENTALISTS

The environmental group's top priority is to educate themselves and to find a way to disseminate educated information amongst themselves. Being continuously against any new technical advances does not give them much credibility among those that they need to convince. Fanaticism, and a keen desire to depict themselves as the only guardians of our environment, causes them to lose the support of knowledgeable and well-intended scientists. It is very difficult to have a constructive discussion with a fanatic individual who is well intended but ill informed.

Technology is changing very rapidly and it is becoming extremely difficult to keep up with all new developments. Instead of trying to do it "all alone against those evil technocrats", they should consider that most people care about our environment. Some scientists will talk to them and expect them to be their voice for things that they cannot oppose within their respective industries. Search these individuals out.

5.14 THE POWER PRODUCING UTILITIES

The power producing utilities will need to initiate plans for the long term conversion to nuclear plants for base loads and biomass for peak and stand by loads. As the current stations age, consider replacing them with hydroelectric, wind and biomass when possible, and hydrogen as this gas is made available. In 15 to 20 years they will hopefully be able to build and commission the next generation nuclear plants to be used for base loads, while converting their biomass and hydrogen plants into peak loads use. Concurrently, operating natural gas and oil fired stations could be converted into stand by units, and thereby extend their useful lifetime.

If the proposed model for the tar sands is implemented the nuclear industry will probably have very little capacity left for more nuclear stations. Utilities should begin building their future peak load and stand by stations now but operate them for base loads. In about 15 to 20 years, the next generation of reactors could be available to start taking over base load duties.

5.15 THE GLOBAL ECONOMY

The global economy needs a controlled and timely change over of energy infrastructure. As witnessed at the tar sands, in a much smaller scale, we don't have the capacity to build simultaneously many mega-projects without causing the prices to skyrocket. The longer we postpone the change over, the more expensive will become the cost of resources needed for this change.

PART 6: THE PROPOSED MODEL

6.1 A SUMMARY OF THE CONSIDERATIONS

6.1.1 At the rate that we consume oil we have on average about 40 years, before this resource has dwindled. With the addition of the exploitation of the tar-sands, this period increases from 40 years to about 100 years. Note that these numbers could vary + or – 20 years, but the situation does not change. Also, at the rate we consume natural gas we have about 20 to 30 years left at best estimates.

A solution to the ensuing problem dictates the timely development of the tar sands along with a new fuel for our long-term energy needs. It also dictates reduction in the rate of consumption of the natural gas.

6.1.2 At present we consume one third of all hydrocarbons produced for plastics, tires, fertilizers etc. Not only does this demand keep increasing but also we will need these hydrocarbons for a long time after we have been weaned from hydrocarbons for our energy needs.

A solution to the ensuing problem dictates that the new fuel development should take place early enough, to conserve some hydrocarbons for the future. It also dictates that new methods be exploited to produce synthetic hydrocarbons from coal. Such actions would perpetuate the production of plastics, tires, fertilizers and other industrial products.

6.1.3 Weaning from hydrocarbons will require a change in energy infrastructure. For such a change to take place, an extra amount of energy will be needed (estimated at 150 billion barrels of oil equivalent) over a period of about 50 years, which can only be produced by consuming hydrocarbons.

Energy infrastructure does not include only the infrastructure of supply. All the existing equipment that consumes energy is designed for oil fuel. Automobiles, airlines, trains, industrial machinery etc, all will need to be changed. It is estimated that conversion will take a total investment of about US $120 trillion. Conversion of our energy infrastructure under panic conditions will only result in panicky increases in price and chaos.

If we want (and I believe that we have no choice), our energy infrastructure to look different in fifty years we will have to start making changes right now.

A solution to the ensuing problem dictates that the new fuel development should take place early enough, while there is a sufficient supply of hydrocarbons available to power the change of our energy infrastructure.

6.1.4 Environmentally, we find ourselves close to the peak of the warming trend of the earth based on historical cycles. Also we have a peak in the CO2 in our atmosphere. Although there are convincing indications that we have not caused this warming, it is almost certain that the excess CO2, over and above its traditional cyclical values, has been caused by our activities. There is the uncertainty that possible mechanisms could be triggered, at this time, which could result in an uncontrollable and non-reversible experiment with possible serious consequences. Do we want to take the chances?

A solution to the ensuing problem dictates that the new fuel development takes place on an urgent basis while every effort is made to reduce CO2 emissions.

6.1.5 Transition to nuclear for primary power will take some time to become effective and to meet the needs of the oil companies at the tar sands. It could take 20 years. The oil companies at the tar sands can in the interim start using syngas for power and heat. Syngas is the synthetic gas made by gasification of coke and asphaltene – both byproducts from the production of crude oil. The capital cost of a syngas fired station is compatible with that of natural gas; however, it burns clean by trapping all the greenhouse gases.

Syngas should be the preferred fuel for power and heat production for any new leases. Incentives should be given to existing natural gas fired stations to convert to syngas. As nuclear power becomes available for electricity and heat, oil companies should continue to produce syngas which could be used primarily as a feed for chemical industries (fertilizers), and also as a feed fuel for standby power plants at the tar sands.

6.1.6 Making adjustments and finally changes on the type of fuel that we depend on, and also on the way that we produce it, could prove to be beneficial to all stakeholders. If this thesis is accepted, then the question to be answered is "who will cause these changes to take place and how"?

Government's record of intervention in free markets has proven to be disastrous in the past. The last thing that we need is a "king maker with absolute wisdom". Ideally one would want well-financed companies making informed decisions and voting with their feet (dollars in this case).

6.1.7 To achieve a change in direction, using the free market principles, the Alberta Government will have to overcome four areas of handicap with negotiations and tweaking tax and royalty regimes such that the pace and the direction of development will be influenced.

The first handicap stems from the fiscal terms. A change in the fiscal terms – 10 years ago, combined with increase in oil prices has led to rapid development. The change in fiscal terms allowed the oil industry to recoup all capital investment before paying royalties. This was a reasonable proposal at the time to stimulate investment in an industry that had not seen significant investment in 20 years.

The simple provision of writing off capital effectively insulates industry to some extent from massive increases in capital spending and the ensuing inflationary pressures. Eliminating or modifying this provision, on a gradual basis, would have a major affect on how attractive new investment is for industry, and will adjust the pace of development.

Here also the Government should be aware that 40% of the capital recovered under the provision of righting of capital, represents interest in the oil company's money while the construction is taking place. Another 30% approximately, represents the capital costs for equipment manufactured in the USA or eastern Canada. This means that only 1/3 of the claimed capital is spent in Alberta.

The second handicap stems from the price of natural gas paid by the oil industry for its own consumption. This provision entitles the oil industry to obtain a 75% benefit of the price of gas produced, while the Province of Alberta receives 25% as royalties. This initial benefits ratio sounds reasonable if the gas produced was refined and transported to consumers (this would provide added value, it would distribute profits while ensuing extra taxes for the Government). Furthermore, having a higher volume of natural gas entering the market place would have caused a reduction to the cost of gas for Alberta consumers.

This provision has been misinterpreted that the oil industry owns 75% of the gas in the ground. Oil companies are then consuming some of the natural gas produced, at the source, and paying only 25% of its market price, in the form of Government Royalties. The 75% benefit is not included when oil companies are calculating their income for the recovery of capital. (75% AECO price X 1000 cu ft natural gas consumed per barrel of oil produced). This effective subsidy of the Government to the industry provides a disincentive for the industry to employ alternative energy sources and to reduce their CO2 emissions.

The third handicap stems out of the fact that several new leases have been issued without asking the applicants to use syngas fuel rather than natural gas for their power and heat. The Government should negotiate new deals by giving appropriate incentives to oil companies with new leases to use syngas for the next ten years. In addition a standard requirement should be made that all future leases will use syngas instead of natural gas until nuclear power becomes available. Once nuclear power becomes available then syngas plants will make an excellent stand by source of power. By 2020, since nuclear will be able to provide not only the power and heat needed but also the means to produce hydrogen for the upgrading of the bitumen, incentives should be given to the oil companies to switch to nuclear power by imposing royalties on the consumption of syngas and appropriate prices for in situ consumption of natural gas.

The first, the second and third handicaps listed above provide the Government with sufficient strength to negotiate a fair deal with the oil companies. If successful, with a single stroke the Government will have achieved environmental acceptability, by reducing significantly greenhouse emissions, with negligible losses for both Government and oil companies. In addition, it will reduce the uncontrolled consumption of natural gas and will consume locally produced waste, coke and asphaltene. It will also have given the incentive to the nuclear industry to complete the design for the next generation plants that burn their long lived wastes.

The fourth handicap stems from the structure of the Alberta Government. The Alberta Energy Utilities Board is the policy-enforcing agency. However, AEUB has a limited mandate, it does not make policy decisions, and its entire staff has expertise only with hydrocarbons. No expertise or interest exists for Alternative Forms of Energy. The policies are made at the Department of Energy, which again has no expertise or interest for Alternative Forms of Energy, and no interest to curtail the consumption of natural gas not withstanding the fact that the dwindling amounts of gas, 97 TCF remaining under the most optimum prediction, will be depleted in 20 to 30 years.

These four handicaps, although they were originally very well conceived, and resulted in an investment boom, right now they give the oil industry the incentive to:

a) grow regardless of inflationary pressures by insulating the industry from the higher costs.

b) continue consuming massive amounts of natural gas by insulating the industry from the real cost of natural gas.

c) keep the syn-gas as a back up to be used only when the heat from environmentalists becomes unbearable.

d) continue with business as usual by not having effective policy makers at the Department of Energy.

6.2 THE PROPOSED MODEL

The above considerations (see 6.1) plus the incentives described in PART 5 have formed the foundation based on which the proposed model was built. Five basic building blocks (concepts) are used:

(i) Nuclear power technology does not deserve all the problems attributed to it. At best it is simplistically touted as an alternative energy source to avoid greenhouse gas emissions from the fossil fuel we now depend on. It is more that that. It is an energy source, which can be developed to launch and sustain the hydrogen fuel era for society, sustainable far beyond the time available with dwindling fossil fuel supplies.

(ii) The tar sands are touted as a source of hydrocarbons, which will extend our supplies to about 100 years. It is more that that. The size and location of the tar sands, as well as the strategic timing of its exploitation, provide an energy source, which can be developed to launch, power, sustain and finance the transition period from hydrocarbons to hydrogen. Alberta based companies have the opportunity of becoming tomorrows "Microsoft" in a changing infrastructure.

(iii) Reviewing the fiscal terms and the price for domestic consumption of natural gas would be the best method for Government to control the pace of oil sands investment and to cause a controlled change in the use of energy.

(iv) Developing alternative energy policy at the Department of Energy and equipping the AEUB to cope with the problems of implementation.

(v) Nuclear power at the tar sands will take about 20 years before it can produce all the power and heat required. Meanwhile syngas should be the preferred fuel for power and heat. This will reduce the greenhouse gas emissions considerably and also will eliminate a locally produced waste of coke and asphaltene.

6.2.1 Based on all the above, in order to get the most out of the tar sands, the following steps are proposed:

6.2.2 2006: Establish a new entity perhaps within AEUB that deals with Alternative Forms of Energy. This entity sets a timetable, to be responsible for and to administer the development of alternative energy. Let's call this entity Alternative Forms of Energy (AFE)

The Department of Energy makes an announcement to review its policies for the current fiscal terms and to implement gradual changes over the next 10 years. Thus giving time and financing for the oil industry to adjust. The oil companies are given incentives to maximize the use of syngas fired power plants for electricity and heat requirements.

AEUB continues issuing new leases. However, any new permit and lease will be subject to the oil company's willingness to cooperate and to adjust its development in line with the new policy changes.

6.2.3 2007:AFE will negotiate with the nuclear industry the following contract:

1) A nuclear reactor prototype to be commissioned at the tar sands by the year 2013. Design criteria for this reactor are developed with input from the oil industry. This to be financed by the Government and when proven viable to give the industry the option to purchase it.

2) An option for 10 more nuclear reactors, to be exercised in 2013, upon successful completion and proof of functioning of the first prototype, to be built at a rate of 2 per year, and to be commissioned in years 2019, 2020, 2021, 2022 and 2023.

3) The nuclear industry will own the spent fuel that will be produced from these plants and will be responsible for reprocessing it. AFE will store this fuel for them temporarily.

4) Within 4 years from ordering of the first nuclear reactor prototype, the nuclear industry will commence the development of the next generation of reactor that with increased safety will be able to consume all the spent fuel produced, by thermal reactors.

5) Within 16 years the nuclear industry will have the obligation to build the next generation of nuclear station that will consume all the spent fuel produced by thermal reactors.

6) Failure to meet the agreed milestones will trigger cancellation and financial penalties.

6.2.4 2008 Department of Energy makes policy announcement to gradually increase the cost of natural gas consumed in situ over the next 10 years.

2008- 2022: AEUB monitors the development that is taking place in the tar sands and develops incentives to the oil industry to entice them to convert to other forms of energy for power production, heat generation and hydrogen production.

6.2.5 2009-2024: AEUB performs studies to optimize the availability of water and to plan if needed for pipelines and desalination stations.

6.2.6 2013-2014 the first prototype nuclear reactor is commissioned and begins operations to demonstrate its feasibility. AEUB initiates a study to examine the feasibility of pumping hot hydrogen with hot steam to upgrade the bitumen in situ.

6.2.7 2014: Upon successful operation of the prototype AFE exercises its option for the additional number of nuclear plants that will be needed by the tar sands development.

6.2.8 2011: The nuclear industry commences the development of the next generation nuclear reactors with advanced fuel cycles to consume the currently produced spent fuel.

6.2.9 2014-2019: AFE and the oil companies operate the prototype nuclear reactor and develop specific design criteria that they need for the production of bitumen. They also develop a plan for the recruitment of operating staff.

6.2.10 2019: The nuclear industry commissions 2 more nuclear reactors. From this point on, the oil industry is encouraged to finance and own any number of the additional nuclear plants. Free market forces control these transactions.

2020: The nuclear industry commissions 2 more nuclear reactors.

2021- 2023 the nuclear industry commissions more nuclear reactors as the progress for hydrogen production dictates.

6.2.11 2024-2026: The nuclear industry commissions the first "next generation" reactor at the tar sands. This takes place as the oil companies have all the energy that they can use. The excess amount of energy is used to produce hydrogen, which fed into pipelines, reaches populated areas in the S, SE and E of North America.

6.3 CONCLUSION

This paper advocates that past agreements must be honored. However, we should not continue issuing new agreements on the same old basis. The use of nuclear power provides a much lower cost of energy than using coal or natural gas at its full market value. The Department of Energy must re-formulate policies to review past fiscal terms and past pricing of natural gas, both of which are now giving the oil industry a disincentive to implement changes that benefit society. In addition, it provides a method with which the oil industry can produce all the energy and all the hydrogen that it needs without producing CO_2. Such a solution must eventually occur because natural gas seems to be depleting at a much faster rate than the oil in the tar sands.

Exportation of unprocessed bitumen should never be accepted as it gives control of the hydrogen market to US based firms' short changing Alberta in the process.

The old argument that we have a free market in Alberta may no longer be valid. We do subsidize the oil industry's bottom line through fiscal terms and pricing of gas consumed at the tar sands. These subsidies tend to influence the free market in the wrong direction. The word "wrong", is used to mean "in terms of maximizing the benefit to Albertans".

Society will likely be using nuclear power at the tar sands, regardless if this will be the result of Government actions now, depletion of natural gas in 20 – 30 years, or environmental problems any time they become critical. The main point is to urge both the Alberta Government and the oil industry not to stop once they have managed to use nuclear power in the tar sands for their oil production and for their own hydrogen needs.

a) Use the nuclear power to produce more hydrogen and feed it to the pipelines as alternative fuel. An announcement of such intent will cause the auto industry and the retail gas suppliers to scramble for positions to take advantage of the clean fuel. In this manner, you will be creating a new and long lasting market for products produced by Alberta based oil companies. It will take about 20 years before the oil industry can start serving this new market.

b) Use the nuclear power to reduce the volumes of toxic pond liquids, and to solidify them. Once solidified these toxic wastes can easily be mixed with clean sand and buried in the 200-foot deep pits. With little extra cost the toxic ponds problem could be resolved.

c) Use nuclear power to desalinate and pump through pipelines all the water that the oil industry will need.

d) Use syngas during the next 20 year transition period to remove and burn by-products coke and asphaltene and at the same time reduce considerably the emissions of greenhouse gases.

The tar sands, with their nature, size and strategic timing, provide Alberta with the option of launching and sustaining the hydrogen era. Alberta's prosperity for many centuries will be secured. All that is needed is a long-term vision and a proactive leadership by both Government and Industry.

When making a rope, one starts with a core string, around which all the other strings are coiled. The Government of Alberta is called upon to form the core string and to give incentives to the coil strings - the tar sands, oil companies, nuclear industry, wind energy industry, biofuels industry and environmentalists to wrap themselves around their core. The resulting rope should be strong enough to carry humanity away from the eminent crisis.

PREDICTION: The day a nuclear plant will start operating at the tar sands will signal the dawn of the hydrogen era.

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Cosmos Voutsinos, a native of Greece, immigrated to Canada 42 years ago. He earned a Bachelor's in Mechanical Engineering – System Dynamics & Controls from the University of Waterloo and a Master's in Mechanical Engineering – Thermo-fluids from McMaster University.

Cosmo's career progressed from designing systems in the Canadian nuclear industry to construction management in the US nuclear industry and Taiwan. He then continued on to a Consulting carrier specializing in Engineering Economics. Here is where he designed Taiwan's power structure to include LNG ports & plants, coal ports & plants, oil fired plants and hydro plants all integrated to ensure a reliable power supply, in the event that military and/or political actions succeeded in blocking the country's energy supplies.

Cosmos sold his company to Taiwan interests and took this opportunity to realize a life time dream to buy a sailboat and go cruising. After crossing the Atlantic and exploring the Mediterranean and Caribbean, he returned to Canada and started a manufacturing career. His new company designed and manufactured control systems capable of operating in a hostile environment. His clients were the military, as well as the nuclear and aerospace industries. In 2002 Cosmos sold his company and retired to Lethbridge.

He now divides his time between Lethbridge and winters onboard his boat in the Caribbean.