An Integral Conceptual Approach to Sustainable Energy and Water Supply

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There are many elements considered to solve the energy and water problems along with the climatic changes, environmental, economical and strategic issues. The approaches to the above have been fractional and not necessarily coherent. This has led to solutions which are not only partial. They are often inconsistent, short sighted, and even contradicting.
We shall try to suggest an integral approach that would relate to a wider view and try to lean on the basic physical laws, economical, strategic and less sensitive to erratic changes.
Some of the major elements involved are: climatic changes; periods; amplitudes and causes; predictions and prophecies about climatic changes; men-made greenhouse gases - how seriously to take them; are there other reasons to get out of the Fossil Fuel Age? Can we define a reliable criterion to avoid the use of fossil fuel? Are there preferred solutions? For example, those that have a positive feed back to climatic changes: What is the interaction between energy and water production and different other targets; what is the effect of water pollution? Can we produce an integrated cheap solution which does not come to a conflict with traditional agriculture and does not contradict simple rules of economics? etc.
I believe we can provide very attractive overall concepts that will revolutionize most or all the exiting concepts.
I cannot avoid also to recognize a lot of considerations which are srongly effected by economical an politicaalinterests of individuals or individualorganizations. Otherwise it is impossible to explain some of the amazingly unwise steps.

1. Introduction

There are many elements that can be considered for the above, in a fractional and not necessarily coherent form. Thus they are leading to solutions which are not only partial. They are often inconsistent, short sighted, and even contradicting.
We shall try to suggest an integral approach depending on a more profound physical analysis, on an economical analysis, strategic and a manner less sensitive to erratic changes.
Some of the major elements involved are the following:

- What are the climatic changes, periods, amplitudes, not only temperature change but humidity winds sea water mixing etc. and what are the causes?
- Can we rely on predictions and prophecies of different climatic lecturers and movie makers?
- Are the men made greenhouse gases really the cause of these changes?

- Are there other reasons to get out of the fossil fuel age? Can we define a reliable criterion to reduce or totally avoid the use of fossil fuel?
- Where are we led to by the above rules and by elementary thermodynamic laws?
- Are there preferred solutions, for example, those that have a positive feed back to climatic changes and several by products?
- What is the interaction between energy and water production and different other targets?
- How can we produce an integrated cheap solution which does not come to a conflict with traditional agriculture?

I believe we can provide a very attractive overall concept that will revolutionize all the above and point out possibly other preferred directions for research and development.While the main research and develpement should be devoted to commercially attractive plans , it is atill important that even if some concepts do not seem to lead at the moment towards specific , attractive solutions this is not necessarly a reason not to support earier stages of research.
It would take a whole book to explain it and defend it. I shall try, however, to sketch it in the following and I apologize that it will not be written in the common way, loaded with a voluminous writing and with hundreds of references, and notes.

2. Climatic changes

There is no doubt that there are changes in the temperature of the atmosphere, in the humidity and the amounts of rain. However, there is also no doubt that there has been changes in the global climate long before people were burning fossil fuel and produced very large volumes of greenhouse gasses, such as carbon dioxide, methane and others. (By the way the "strongest" greenhouse gas is, by far, water vapor). There are evidences of very large changes in the seas levels. There are floods records and dry spells within tens of yeas periods, hundreds of yeas and thousands of year's cycle. This is in addition to the daily cycle synoptic cycle annual cycle and a short series of dry years. This happened where human society was still leaving on food collection, when there has been already agricultural activity with datable archeological remains and such changes that remained in the human written memories. There are the repeated stories of our forefathers, each going down to Egypt because of famine in the Holly land. Joseph interpreted the dream by Pharaoh about sever fat years and seven dry ones. There was the3 Noah flood. I wonder if this happened because they have used too much fuel for transportation or for producing electricity.
At the present dry spell in Israel some authorities say that "eighty years there was no such crisis". However this means that eighty years ago there was such a cycle. Beyond this argument I must report that I was called to take the place of a Water Commissioner in 1990, after my predecessor did not do a thing for nearly ten years ending up with a dry spell probably worse than the present one.

The analysis has shown since the late sixties, that are 40 years ago, what is anticipated and what should have been done.

I have taken the record of hundred and fifty year's rain measurements in the City of Nobles (called Nablus in Arabic and Shchem in Hebrew), drawn by Professor Yoav Kislev and his co-worker (fig. 1). I have calculated a running average rain over 25 years. The averages have shown several cycles between a maximum of about 800 millimeter and a minimum of less than 600 millimeter rain. In any case there have been cycles at any frequency up t 160 years. Now any person in a hurry may find himself on an up going pat of some cycle or downward andthus leave a freedom for a lot of fruitful arguments.

I have been invited to give a guest lecture in an international convention of the World Weather Organization (W.W.O.). Never mind my lecture. A young scientist from the World Bank reported a research showing that damages due to natural catastrophes were growing larger as the local governments did not do what should have been done without having to get the quality of a prophet. Very notably, such natural disasters have been taking place hundreds of years in back record.

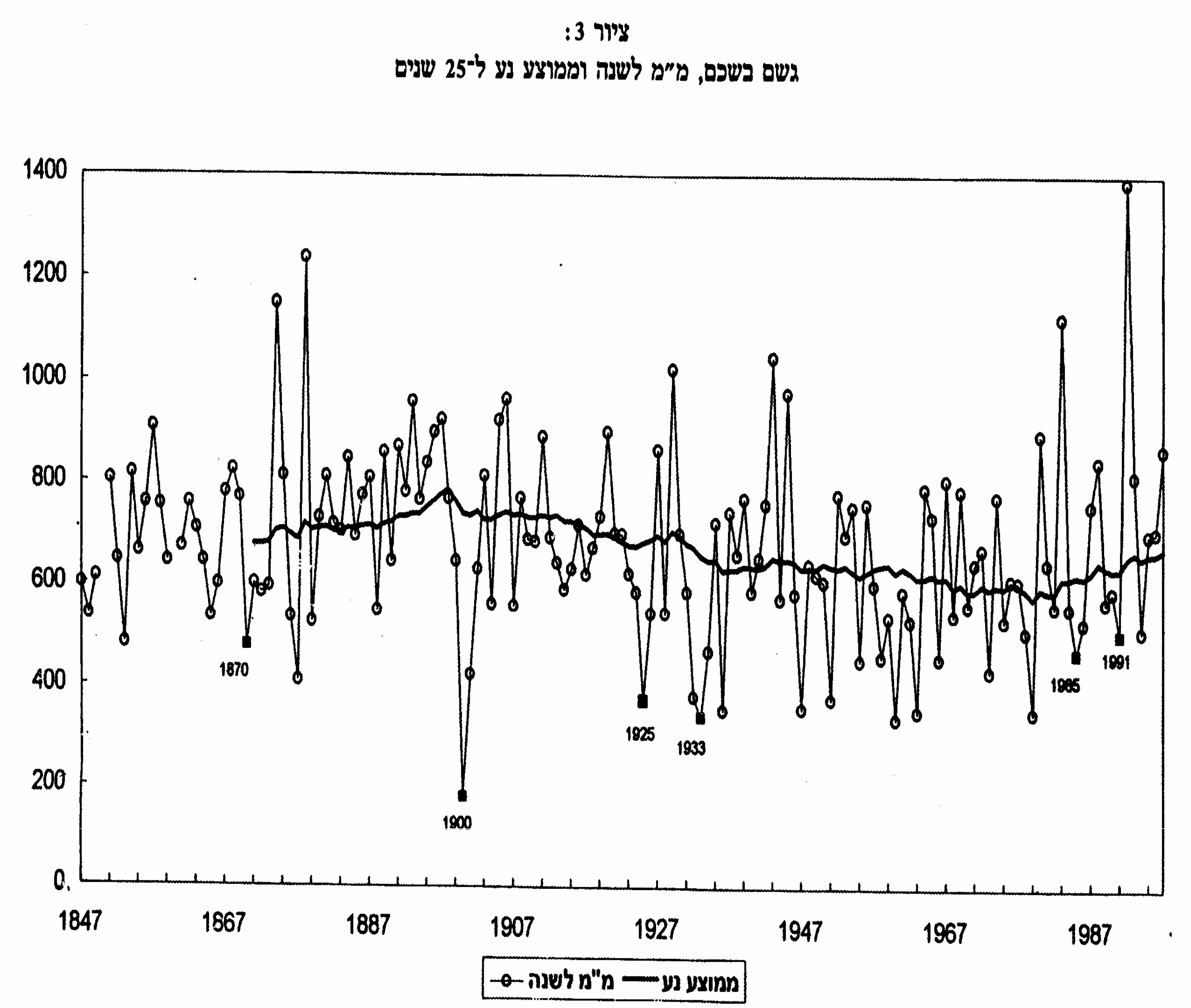


Figure 1 - Rain measurement in millimeters over 150 years in the city of Nobles (Scheme), Israel

These observations alone lead to some very far reaching conclusions.

- It is difficult to predict what are going to be the climatic changes and we are certain that there will be ups and downs with different frequencies, starting with daily ones, few days synoptic ones, annual ones, a group of several years, etc. The longer the period the larger could be the amplitude. However, the longer the cycle, the more time we shall have for meeting the troubles caused by the wrong investment. This very fact dictates the type of policy needed. The largest observed problem is having ignorant and irresponsible administrations, looking for ways to leave the disaster to those who will come in at a later date, very often too late. Why should they give a damn if it is going to take place and cause a great damage long after they are out of office?

- It is almost impossible to predict exactly enough the probability for a change and the extent of damage to be met. Let us use flood protection as an example. If the decision maker would consult an intelligent engineer, he could find out that the maximum anticipated rate of flow would increase with the anticipated time to the power 0.2. This is a well established statistics around the world. The discharge of flood in a pipe that has to pass the flood water would increase in proportion to the diameter of the pipe to the power 8/3. We can observe a simple example. Consider the need to contain peak flood water in a round conduit. With these two facts, it is easy to show that if we wish to extend the statistical return period 10 fold we have to increase the pipe diameter only by 19%. If we wish to extend the return period 100 folds, we have to increase the pipe's diameter only by 42%. As you see, a smart design can point at very smart ways with very small cost.
- These lead us not to carry on an endless debate whether it is justified to replace the use of fuel and how much is worth paying for such action. Though, it will give some things to do to a huge number of scientists, a case to get rich prices for a movie (see a Nobel price for Al Gore, former Vice President of the United States). See also a new book that come out, written by the famous newspaper man of the New York time - Mr. Tomas Freedman, who already has received an honorary doctorate for his beautifully narrated and fluent lecture which is very far from the real picture and ignorant of the available solutions.
- **The Kyoto Protocol reminds very closely the Inquisition threatening Galileo, not to say that the globe surrounds the sun and not the other way around. Moreover, it reminds the permission to sin if one is ready to pay the "indulgences" inflicted, then, by the same church.**

3. Are there other reasons to leave the Fuel Age and what should be the criterion for a new technology?

3.1 The reason we left the Stone Age

One of the most interesting questions about the men in the Stone Age is why they have moved from the Stone Age on. Is it really because they ran out of stones? Is it because stones were expensive? Or is it because the use of stones has spoiled the environment?

The urgent need to find substitutes for fossil fuel is not necessarily because we run out of it, and not necessarily because of global warming and not even only because of cost.

A new debate has started. What is most important? Replacing fossil fuel or even reducing its use or concentrate on helping the poor? This debate assumes that the fuel substitutes for energy are, by definition, more expensive but there are strong reasons to stop using the fuels as strong as the most serious humane values and still with no contradiction to common economical yardsticks.

Leaving the Stone Age was very expensive, especially for all the short sighted characters. Think what it takes to discover metals, glass and ceramics, to learn how to use them and start an industry. What did it take to develop the use of lime for construction and the cement obtained by mixing the lime with volcanic ashes or grounded burned clay which is very close to the Portland cement ? Would there be any king or priest that would put large means for doing these? In all probabilities they have found reasons to prevent it without any obligation to justify it by good reasons. We must be aware of these processes, that are slowly promoted by special characters and make it possible to promote their creativity. This is one of the most important tasks which unfortunately is very badly handled. How come that Al Gore receives the Noble price for his very questionable contribution to the environment? Why it was not granted to a person who showed the way to replace about 30% of fuel burning? After 25 years he is still struggling with authorities for help. Just recently he was granted for his work 1/7 of the additional price received by Al Gore from a fund in Tel-Aviv University.

There is a whole list of problems involved also with the use of fossil fuel under the present day global situation. It is a wonder why is it that the vast majority of spending to change the situation is directed to crazy expensive methods producing electricity ten fold more expensive and that are operational only one third of the day, How come? This is while it is possible to reduce the fuel use and transform to sources of renewable energy which are not necessarily more expensive. Of course, where it is done in a wrong way, it is certainly not attractive economically and calls alternatively for carrying ideological flags.

In most of the cases when there is a conflict between common economic rules and environmental preferences. It is not because we have to pay high prices for our environmental ideology, but because of extremely poor design and decision making and most often simple ignorance. In this brochure you may find several such concrete examples as at the end of the above section, the whole of section 5 and the list of the by-products in section 6.7.

The debate about staying with fossil fuel is led most often by conservative people and financed by oil companies. The other extreme is led by people that not always can prove their point. They are raising a flag and fight for it. **The different flags do more to fight each other rather than trying to do the best. Do we have a way out of this debate?**

These days there is a consensus that the main problem is the emission of greenhouse gases, mainly CO_2 by fuel burning. There are very sound proofs that volcanic changes in the globe, changes in the solar radiation and the path of the globe around the sun are the main causes for climatic changes, for the formation of ice or its melting. They are not man-made.

It should be said again - Any attempt to argue with this point meets the reaction that reminds the Inquisition that have warned Galileo for arguing that the globe goes around the sun. Furthermore, part of the whole Kyoto Protocol's philosophy is that one may buy the so called "indulgences" so that he can keep on living in sin.

3.2 The real reasons we should consider moving to renewable energy sources and lea eth fuel age.

3. 2.1 Finite sources of fossil fuel

There is absolutely no debate about the statement that these sources are finite. There is a lot of debate about how much is left and how serious would be "the effect of a last minute" change in the energy source.

Even the optimists admit that long before we run out of fuel, the resources which still exist, will become more and more expensive. This is because the cheaper resources have been used first and because those who were left with the resource will blackmail the users even worse than now. The life expectancy of oil and natural gas is only few decades. Coal could be supplied much longer, but not long enough to delay the search for alternatives.

3.2.2 Local environmental damage by the burning products

There is absolutely no question about the fact that burning fuels in power stations, in space heating and in vehicles transportation, pollute the air. The number of people who die due to such pollution in urban areas exceeds the casualties by road accidents by an order of magnitude. In Tel-Aviv it has been estimated that 1100 people die every year of air pollution. There are very high percentages of people, especially children, who suffer from breath system diseases.

A most recent estimate by "Pareto" for the ministry of envieonmental protection argue that the environmental damage from tall chimneys through human illness and death is about 20 dollars per ton of Carbon Dioxide. It is about 3250 dollars per ton of nitrous oxide. It is about 4300 dollars per one ton of certain particles and 4300 dollars for one ton of sulfuric oxide. This is for chinmneys taller than 100 meters. It is far more for low chimneys and transportation. Estimated damges made in central Europe are far higher and add up to more than 20000 dollars per ton for each of he main componenets.

Measurements of solar radiation made in Israel (Beit Dagan) showed that over the years the traffic pollution have slowly reduced the incoming solar radiation by about 20%. One day a year, when there is practically no traffic - the Atonement Day (Yom Kippur) - the sunshine goes up again coming closer to the original value.

It is possible to attempt translating the above into economical terms. If for example one human life and medical treatment are estimated at a value H and there are N deaths. The product N*H could become 10 billion Shekels per year, in Israel. This adds up to a couple of hundred dollars for one ton of oil equivalent and almost 30 ¢/kWh.

3.2.3 More Environmental effects

The environmental effect may not be as dramatic as the "Kyoto Protocol" people think. However, it is certain that some negative effects exist.

There are several excellent studies that have estimated these damages, as in the following.

13 scientists (Robert Constanza et al: "The value of worlds eco-system services and natural capital", Nature, Vol. 387, 15 May 1997, pp 253-260) estimate 17 global functions which serve the sustainability of life on earth. Among them: gases control, climatic controls, control of large disturbances of global systems, water control, water supply, erosion and precipitations, soil formation, nutrients circulation, waste handling, flower pollination, populated biological control, dwelling sites, food production, recreation, culture.

It has been definitely shown that the use of fuels and especially their burning has some effects on these recovery systems. A conservative estimate of the annual contribution of the 17 systems across the globe (16 different landscape units) is 3326 trillion dollars per year ($33X10^{12}$).

The maximum estimated value was $55X10^{12}$ $/year and the minimum estimated value was $16X10^{12}$ $/year.

Moreover, the estimate was that the system reacts in a non linear way. If the system tends to more extreme values away from the steady states balance condition, the damages rate tends to increase.

As an illustration, consider 1% change or about 0.33 trillion dollars per year. If this is caused due to the human production of 30 trillion kWh a year (including not only the electricity), this means a damage of about 1 cent/kWh.

Some estimates are that the actual damages are in the order of at least 2% and in some cases even more. The list of examples is very long.

I shall avoid getting into detailed arguments pointing very definite damage. One poetic expression is: "People passed a threshold from using the "interest" and started consuming the "capital" or the "principle". It would take a new leadership to meet the complex threats which can be predicted.

Reviewing many investigations concerning the "communal external costs" of using energy, I came up with the following range of values.

Table 1 - External cost of producing electricity

Fuel	**Minimal external communal cost**	**Reasonable choice of external cost**
Coal	1-2 cents/kWh	6-7 cents/kWh
Oil	2 cents/kWh	6-7 cents/kWh
Natural gas	1 cent/kWh	2 cents/kWh

Such values, if they are accepted, (and there are arguments that they are much much higher, especially if we include defense expenses and the value of human life) can lead to an estimate of what is the permissible investment in order to avoid the communal external costs.

Table 2 - Permissible extra investment due to elimination of extra costs in Dollars per average installed kilowatt

Source of electricity	**Minimal external communal cost [¢/kWh]**	**Extra investment per average kW for delivery**	
		5% interest rate	10% interest rate
Coal	6-7	8078-9425	15770-18400
Oil	6-7	8078-9425	15770-18400
Natural gas	2	2693	5256

With such worthwhile investments, the problem to adopt alternative sources of renewable energy becomes easier. However, the best solar energy source for electricity is barely justified economically by these figures. This alone lead , in all proability some investiugators to exaggerate about the estimated dsamages and thus set up the permition tonuse very 0065pensive alternatives. The most advanced method to use solar radiation for electricity showed recently a production cost of 15.5 ¢/kWh. This is to serve 8 hours out of 24. The anticipated investment for 24 hours supply far exceeded the above values and at the bottom line we cannot replace about two thirds of the fuel use over and above the solar investment for the other third. The investments comparisons should be by the so-called cost per average kilowatt.

Alternatively we would have to invest in an expensive storage system and have a definite loss of energy in the transactions needed.

To make the production possible withut taking care of the rest of the two thirds of the day , the Israely government had to offer 20 cents per kWh. And still there areno many running to build such unuts.

The other very popular and heavily subsidized supply of electricity from solar radiation is by photovoltaic cells. The latest value published by the Israeli government is allowing to install 50 megawatts of such cells and the pay promised is 2.01 New Israeli New Shekels (57 cents, August 2008) per kWh, also for less than a third of the day.

Even if somehow one could, after all, convince us that it is justified to use these very expensive solar systems it is necessary to test them in comparison to other alternatives which are cheaper or which have other advantages**. I must already say right here that at present there are such alternatives far exceeding these two. I cannot possibly understand the readiness of governments to subsidize so heavily the two solar methods using the solar radiation for massive supply of electricity. I can understand even less private people that buy with their own initiative photovoltaic cell for their electricity supply. It sounds more like a public hysterics and possibly some administrational vested interests. It could also be the result of ignorance, on one hand, and a wish to demonstrate some doing to the public, on the other hand.**

The Israeli Government committed to up to 50 Megawatts. As far as electricity supply is concerned it would mean practically only a little more than one part in thousand out of the Israeli electricity consumption, a very large spending of roughly 2.5 billion dollars. Certainly not more than 2 parts in thousand. Still it will serve as a demonstration that we do something. Later on, we could say that the extent of photovoltaic use increases more than ten fold, simply because before that there was hardly anything. This sounds much better.

3.2.4 The high cost of the fuel

Several years ago when the cost of a barrel of oil was less than 10 dollars, I was among those who predicted a rise in the costs (30-40 dollar per barrel in 2005). I didn't dare to suggest that it will reach over 70 dollars in the mid 2007, and during June 2008 it is around $140 per barrel. This is something that many countries cannot afford. The prices are going up and down with different amplitudes for different periods. These days it came down from over 140 to 110 dollars per barre and in Januaryy 2009 It came down and rocks between 35 and 40 dollars per barrel.l.

Note that if many of the cheaper fuel resources will be exhausted, the fossil fuel power stations that are being built today will become obsolete within few years. Also new methods to use renewable energy will become much cheaper. At least so we hope. So, why waste more money on the traditional fuel operated power stations?

The high fuel costs should drive us to have new thoughts about many things. I do not think we should take seriously self made experts like a good architect- theater actor that said we should leave the periphery and go and live in very tall and dense houses so that we do not have to rely on transportation. However, if the best desalination method today requires 4 kWh electricity per cubic meter desalinated sea water, then the cost of the water may change from about 50-56 cents per cubic meter early last year to nearly 140 cents soon two and a half fold. This would change the extent of water use for the fundamental human needs. Moving to high rise buildings in town is not going to solve this problem. It means that we do not have desalination as a solution unless we invest in a better method or find a cheap renewable source of energy, or even better, both.

3.2.5 Price fluctuations damage

It can be shown that fluctuations of oil prices cause an unbelievable economical damage Assuming an economic function Y (for example the net domestic product N.D.P.) and Y is a function of the oil price P in some manner, Y can be expressed then by:

(1) $$Y = Y_{\bar{P}} + \left(\frac{\partial Y}{\partial P}\right)_{\bar{P}} \Delta P + \frac{1}{2!}\left(\frac{\partial^2 Y}{\partial P^2}\right)_{\bar{P}} (\Delta P)^2 + ...$$

A simple Taylor' series expression of Y as a function of P (subscript $\bar{P}$ reads "at average P"). One can now calculate the average Y by integrating equation 1 over the time t and divide by the total time period T.

(2) $$\overline{Y} = Y_{\bar{P}} + \left(\frac{\partial Y}{\partial P}\right)_{\bar{P}} \frac{1}{T}\int \Delta P dt + \frac{1}{2!}\left(\frac{\partial^2 Y}{\partial P^2}\right)_{\bar{P}} \frac{1}{T}\int (\Delta P)^2 dt + ...$$

$$= Y_P + \frac{1}{2!}\left(\frac{\partial^2 Y}{\partial P^2}\right)_p \sigma_P^2 + ...$$

Where:

$\overline{P}$ average value of oil price in this case around which one calculates the derivative and the integral;

The first term $Y_{\bar{P}}$ is a constant;

The second term vanishes as the sum of ΔP around $\overline{P}$ is zero.

The third term is

(3) $$\frac{1}{2!}\left(\frac{\partial^2 Y}{\partial P^2}\right)_{\bar{P}} \sigma_{\bar{P}}{}^2$$

Where $\sigma_{\bar{P}}{}^2$ is the variance of P around average $\overline{P}$.

The fourth term would be:

(4) $$\frac{1}{3!}\left(\frac{\partial^3 Y}{\partial P^3}\right)_{\bar{P}} \mu_P{}^3$$

The term μ^3 tends to vanish because the third power of the fluctuations is relatively small, and because the values are more or less evenly distributed around $\overline{P}$ with positive and negative values. We can write the final approximate result as:

(5) $$Y \cong Y_{\bar{P}} + \frac{1}{2}\left(\frac{\partial^2 Y}{\partial P^2}\right)_{\bar{P}} \sigma_P{}^2$$

In relative terms Y compared with $\overline{Y}$ at a fixed average oil prices $\overline{P}$ we get

(6) $$Y \cong 1 + \frac{1}{2}\left(\frac{\partial^2 Y}{\partial Pr^2}\right)\sigma_{Pr}{}^2$$

It is easy to show that the value of the second derivative near optimal economic operation is negative (a second derivative near a maximum). Moreover, it is easy to estimate that the absolute value of the derivative will be close to a unity, and possibly higher.

Calculating the variance of oil price relative value in the second half of the 20^{th} Century, is several percents and over shorter periods even more than 10%. The extent over he last two years the value of the variance is close to 1/2. And the damge is close to one quarter of the N.D.P.

This means that the very fluctuations of the oil prices cause a reduction of functions like G.D.P. by several percents per yearan can reach even several tens of percents.. This is a very high damage over and above the increasing fuel costs and the environmental damages.

3.2.6 The losses for defense

It has been estimated by a team in Princeton, U.S. in 1992, that when the cost of gasoline in the US was 30 cents per gallon, the weighed cost of defense, the preparations for war and spending for two actual wars directed to safeguard the fuel sources cost in addition about 70 cents per gallon of gasoline.

At the present, the US spends huge sums of money to overcome the arbitrary regime that was in Iraq. In April 2006, the American Congress estimated that the cost of the war in Iraq has reached 280 billion dollars in less than one year. It also gets huge sums to maintain a strong army in Saudi and in other countries. The US government spends huge sums to support the potential allies. This has cost about $ 1,000 per person per year in the U.S.A., and very possibly more. If this finding is related to electricity use, it amounts to over 7 ¢/kWh. However, the government is still afraid to embargo Iran's oil export to prevent it from producing atomic bomb because the blockage of Iran's oil will increase the fuel prices even more than they are now. Thus we demonstrate one of several mechanis by which the status of the fuel se lead to other seemingly un related damaqges.

3.2.7 Loss of possibilities to exercise freedom and the battle between cultures

Countries undertook all kinds of means to ascertain the supply of fuel. Therefore, they have built fuel storages, made long term fuel buying contracts, which both are very costly.

For many years Europe has yielded to Islamic culture demands and gave preference to Islamic infiltration of population. In fact, Europe risked the freedom of its life. It is now being threatened by very large populations full of hate, superstition and with low values of human life and human dignity, telling the truth, and other indicators. The oil fields, which finance global terrorism, are run by corrupt and cruel leaders who speak in the name of God.

Oil merchants accumulated trillion of dollars by which they can buy the economical elements of the western countries. They can even buy simply foreign currency and inflict economical blows whenever they fill like it or when it goes out of hands.

3.2.8 Another criterion possibly the ultimate one for deciding if a technology for renewable energy is economically viable

It is difficult to settle the debate on the extent of damages to the environment and the probability that it is manmade due to the use of fuel. It becomes most difficult if we want to include secondary efforts in our modern world with such expenses such as security, economical stability, etc. Moreover, the facts that a certain alternative is justified by the worst, does not necessarily mean that there are still even better ones.

We can define a ratio R as follows:

$$R=\frac{P(D)}{(1-P)E}>1 \quad ,$$

Where:

P the probability that there will be a damaging change in climate or any other change;

D the estimated damage we shall have to face;

E the extra cost of an alternative energy source which is clean and will prevent the damage.

In order to justify a change to use an energy source without fuel, R must be larger than a unit. In other words, the extra cost of another energy source which, in all probability, will eliminate the damage by using fuel, must be smaller than the probable anticipated damage.
The main struggle should be to obtain sources of very small E and possibly even negative.
I cannot see P and D being agreed upon. However, in a simplistic way, one can say that if the alternative energy source is cheaper than energy source that use fossil fuel - then who cares if P is high and D is high or not? We shall prefer the alternative.
If we are lucky enough and can show such technologies where E is very small or better even zero or negative, we have to leave the Stone Age not necessarily because we are out of stones or because stones are expensive. Well, we are lucky. With a series of known solution we can show reduction of fuel at the extent of 50-60%. With a new technology we shall show the possibility to replace nearly 100% of the fuel use. We shall be even luckier if we find a way to produce fuel which does not have the disadvantages of the fossil fuel and it does not lean on fossil fuel and it is still cheap. We may show that some of the by product of renewable energy technology is not only supplying cheaper and environmentally clean electricity. It will supply us with a bounty of cheap fuel replacement for transportation without any net emission of greenhose gases. More over, a bounty of water at half the best present cost can be produced.

3.2.9 How much renewable energy is available and how expensive is it

Providing alternative sources of energy which are renewable and which are better distributed around nations will create a movement towards another age, like coming out of the Stone Age by ancient

people. There are many reasons to do it even if we are not convinced that there is going to be disastrous change in climate, just as it was justified to leave the Stone Age.

The industrial revolution was a transfer to a new age. It came along with learning how to use very high concentration of energy sources brought very conveniently by fossil fuel. It is the time to try and move into a new age.

The questions are:

1. **What are the available sources today?**
2. **How much renewable energy is available and how expensive is it?**
3. **In what directions do we have to develop more new sources of renewable energy?**
4. **Can we, or should we, delay the exhaustion of cheap fuel sources by better solutions right away? Or do we have to wait until we have still better solutions?**

We can come up with practical criteria where the environmental can justify the change to renewable. However, using the other reasons mentioned above, maybe we do not have to wait until everyone is convinced by the externalities due to environmental argument alone. And - if we find a cheaper source, cheaper than using present methods - why not changing right away? In fact our main criterion is of a normal economic nature. We simply have to look for the cheapest methods. We shall show that such methods do exist. More over these methods would have important additional advantageous and associated by products. It is amazing why the largest efforts to apply alternative energy sources concentrate on those who are 5-15 times more expensive than the presently used ones. Most of them work only a fraction of the day and require huge areas at least ten times more than some other alternative an we shakk show a method that require only about 4% of the area requires by solar method. What is the reason? Stupidity, corruption, or may be a psychological and social problem?

The following discussion will add more considerations for preference of the alternative methods and enumerates the methods that can be applied almost immediately or very soon. It does it very briefly without going into many details.

It is amazing how many attractive possibilities exist. It is even more amazing why these possibilities are not used enough or not used at all.

4. Alternative ways to reduce our dependence on fossil fuel

4.1 Source groups

There are 7 groups of ways to consider in order to reducing the burning of fossil fuel and thus improve the situation not only as far as the "greenhouse gases" are concerned, but for all other reasons that are very real here and now and briefly described in the above.

We certainly do not wish to wait and see who was right in the debates on pollution and global warming. Is global warming man-made? Can it be reversed? What is the damage involved?

Group 1 - Improve efficiency of energy use
Group 2 - Use the fruits of the sun to produce electricity
Group 3 - Use solar radiation to supply heat
Group 4 - Adaptation of the supply curve to the demand luctuations. This could be, for example, by storing energy to meet peak demands and by change of the demand distribution
Group 5 - Use solar radiation to supply electricity
Group 6 - Other sources
Group 7 - Some miss-concepts

There are all kinds of other ideas. We limit our discussion here mainly to massive replacement of energy sources for three main uses: electricity, transportation and heating or cooling. It seems that the first four groups can do most or all of what is needed. The fifth one has good chances to be achieved hopefully after some more development that will take time, possibly decades. The fifth group can be used also in special cases, not necessarily to replace large masses of fossil fuel. It may help solving some special local needs. At the moment, there seems to be no justification to apply them right away on a large scale.

4.2 Efficient use of energy

In Israel it has been shown that 20% or more of the energy can be easily saved in all uses with an investment that will be paid back in less than 5 years. This is true in electricity use, in transportation, in agriculture, industry and in power production. It would mean coming down to 4800 kWh per capita per year in electricity.
In Western Europe the average use of electricity is about 6000 kWh per capita per year. In the US it is closer to 14000 kWh per capita per year. How come? There is no real difference of this magnitude in the standard of living. The difference is simply a result of waste. So, in principle, the U.S. can possibly reduce the use of electricity to half or less - 50% reduction in burning of fuel to produce useless energy!
There is absolutely no doubt that a tremendous amount of fuel can be saved also in transportation by using hybrid cars, smaller cars, and slower cars. We can use more two weels with or without a motor. 3we can enhance public transportation and the use of electricity lines.
There are dozens of tricks to save. Among them: a new technology such as efficient lamps; better building isolation; modern and more efficient air conditioners.
All electrical facilities with remote control waste energy continuously even when they are not in operation. Heat that comes off refrigerator is then picked up by air conditioning. It is possible to save

a lot of energy in obtaining uniform water distribution, it is possible to recover large parts of the energy used for desalination or recover some.

A lot of energy saving can be achieved in India where the worst losses are due to stealing of electricity, high losses of transmission lines and non realistic prices for the energy use that lead to wasteful use.

These are just few examples by which a dramatic effect can be achieved and no negative economical impact as the American Congress is afraid of.

The effort to privatize the Israeli Electric Corporation to start competition is to a great extent an illusion. All it will do as it did in almost all other cases abroad is to raise the cost of electricity and to cause supply failures. The Israeli case would lead to a government loss of nearly 50 billion N.I.S. Probably the most important regulatory change is to allow relatively fast depreciation of investment to be recognized for the tax deduction to replace tax deduction by wasting fuel. The other one is setting realistic electricity prices. Finally, the Government must support commercialization efforts, however, these should not be turned into subsidies to fashionable trends that have no near present economical justification.

4.3 The use of the fruits of the sun

Throughout history men used the fruit of the sun using basically three sources:

- Wind energy;
- Hydro-power;
- Burning of bio-mass.

All three lead today to energy sources which are economically competitive to the use of fuel.

Wind energy can provide in many countries in the order of 20% of the electricity supply and more. It can be very widely extended by relatively slight subsidy. One of the important improvements is to overcome the wind energy intermittency. This can be done, among others, by using low investment and low losses storage systems and large electricity networks which have variable production capabilities. Research and developments in these directions are highly recommended. In Israel old surveys indicate only about 6% fro electricity from wind. For the sake of the discussion here I assume some subside to ring it up to 10%.

Hydro-power is available in some areas, but overall it is far from enabling a revolution in energy sources. The global potential is estimated to be less than 6-7% of the electricity consumption. It has one by-product which is quite important. This is a way to conform the supply of electricity to the demand without the need to build very expensive power stations operated by fuel which are active only few hours during the year. The cost of electricity from such additional power station can become even 5 folds the baseline supply. This can be prevented by hydro power which is naturally available or by pumped storage which can be installed. (The energy loss in pumped storage is about 30%).Israel ha practically no hydro source of any significance.

The bio-mass is a very important source in both developing countries and developed countries. The municipal and agricultural waste in Israel can provide up to 10% of the electricity (about 5 million tons a year and 4% annual increase. Lately 6 million tons were quoted), however, the use of this waste has several very important by-products, such as:

a. Preventing groundwater pollution which is of the same order as sewage water;
b. Preventing the emission of greenhouse gases. In Israel, these are about 1/4 of all the greenhouse gases;
c. Saving land, transportation load and birds that endanger aviation.
d. Recycling ofr important materials

In Israel a method has been developed to handle city garbage. First, individual components are being collected for recycling glass, plastics, ferric metals and non ferric metals. Then, the rest is fermented an-aerobically to produce bio-gas. Two plants are working: one in Israel of 100,000 tons per year, and another one of twice the capacity in Sydney, Australia.

The use of bio-mass can now be extended into a new dimension. A lot of experience has been collected in using Ethanol to replace car gasoline. Certain oil crops can serve to produce oil that replaces diesel fuel. **However, there are limits to these possibilities due to shortage of irrigated land shortage of water and relatively high costs. Today where it is applied it negatively affects the classical agricultural supply and some times replaces natural vegetation.**

The third type of the fruits of the sun is the wind. The wind and bio mass may provide each not less than 10% of the electricity at low production costs, and in some countries even twice that.

In the following I am going to show a way to break these limits and possibly turn some new methods into an unbelievable combination of very cheap electricity from renewable sources and huge volumes of relatively cheap desalinated water and irrigated land that will provide in turn, very large dimensions of replacement also to fuel for transportation.

Note that we can replace in Israel at least 20% of fuel for electricity which amounts to some 7% of the fuel used. We can replace also 30% of fuel for heat supply and easily 20% in turning the use more efficient.

The total replacement of fuel use can thus reach nearly 60% and this is an economically attractive way and almost immediately!

4.4 Other fruits of the sun

There are other fruits of the sun such as temperature differences in the ocean water, wave energy and the use of underwater streams with underwater turbines similar to wind turbines.

So far, none of the above could be proven as economically viable for large scale electricity sources. Moreover, the use of wave energy and water streams could be counterproductive as far as the effects

on rain and other by-products (see for example chapter 7.2).Waves are essential for mixing the sea water. This mixing provides the oxygen for the creatures in the sea. The wave mixing also helps storing heat in the water profile. It has been shown that this heat is essential for the productio9n of rain.

In the next part of this report (no. 6) we are going to describe a revolutionary new source of the fruits of the sun - the "Energy Towers".

We must understand that by using the fruits of the sun we avoid the need for an expensive solar collector. We do not have to worry about transformation of heat to mechanical work at low temperature differences. We are very lucky, however, we find very large volume of this product.

4.5 The use of solar radiation for heat

This group of technologies has very good chances to supply much of the energy that uses fuel today. Using heat at home and in industry is some 30% of the energy use.

In Israel, about 3% of the energy is supplied so far by solar water heating. Much more can be supplied to industry for process heat and for direct house heating. The technology is practically available.

The technology is based on the production of a plate that let through most of the solar radiation but blocks almost perfectly the loss of heat. In small ponds the efficiency of turning solar radiation to heat was about 50%. One can call these plates "thermal diodes".

By using heat storage and some heat pumps, one can cover peak demands of energy at times of extremely high need for cooling and heating. It not only saves fuel, but also high investments for peak demand situations.

As an example - the technology of "parabolic mirrors" which has been used first by "Luz" and now "Solel" in Israel has no more than 10% efficiency from solar radiation to electricity. However, it could have here better than 50% efficiency from solar to heat. It is much cheaper to store heat than electricity. For comparison the extensive work on the solar ponds with salinity concentration gradient, led to 16% efficiency of solar radiation to heat but only a fraction of one percent solar to electricity.

4.6 Solar energy technology for electricity

The two most advanced technologies in that sense areas we have already mentioned:

(1) Parabolic mirrors that concentrate solar radiation on an oil pipe. Oil heated to 400^0 C is used to boil steam and move turbines.

This method was demonstrated by the Israeli company "Luz", replaced by "Solel". However, as was already stated, the cost was recently calculated to be 15.5 ¢/kWh, and this is only for 6-8 hours a day.

(2) The Solar Tower by the Weizman Institute is predicted to have a similar cost and has the same basic limitation like the "Luz" technology. Both require several times, about 15 to 25 fold the area needed by the "Energy Towers" (to be described later) to produce one million kWh per year.

(3) The most popular solar energy for electricity is the photo-voltaic cell. Towards the end of 2005, the lowest cost was about 3 dollars per Watt peak output. Translating it into a cost per kWh brings it to 30-40 ¢/kWh or even more. On July 2008, the Israeli government promised 57 cents per kWh (it has been declared as 2.01 new Israeli Shekels per kWh). This obvious subsidee was fixed after it was well known what the suppliers could provide.

In order to reduce the cost of electricity from photo-voltaic cells, three main concepts were suggested in recent reviews:

a. Concentrate the solar radiation and improve the overall efficiency;
b. Utilize the heat that is absorbed;
c. Replace silicon for the cells with some organic films which have a power efficiency, but possibly a lower overall cost, especially that there is a bad shortage of produced silicon.

However, so far, no one has proved yet these by providing a new product that will cross the economical limit line. The rest is speculation.

On top of the photo-voltaic cells, which are as yet very far from economical, there came the concept of "distributed sources". Basically, this special term tries to place photo-voltaic sources on each roof, and then connect them into an overall electricity supply system.

At least two basic things must be remembered:

a. The local instantaneous installed output is directed by temporary high demand. When large power stations supply electricity day and night to a diversified population of consumers, the overall installed capacity is about twice the capacity that could supply all the need on the average. If we install photovoltaic cells without a huge and a very expensive storage, this ratio would be not less than 5 times the average consumption, and possibly even 10 times - an extremely inefficient and expensive investment!

b. The individual cells are still connected to a large net of transmission lines. The overall result is that we have an impossible expensive system with no horizon to become economically attractive with the exception of very special rare cases. Still, huge sums are spent on photovoltaic systems and it is very heavily subsidized.

4.7 The energy efficiency and economy of hydrogen fuel cells remain unproven

This is an unbelievable story. The use of hydrogen and other gases could be reached in special "fuel cells" and produce electricity at relatively very high efficiency. However, electricity or another source of energy is necessary in order to produce the hydrogen. Today the overall efficiency is not high. The process is extremely expensive because of the need for extra two energy transactions and hydrogen storage. To put it in simple words that may be understood by decision makers: we want to produce electricity from clean sources. So we use hydrogen. But we do not find hydrogen so we are going to produce it. For producing we need electricity so we look for a way to produce electricity from clean

source. Why do I have to use this electricity to produce hydrogen so that I shall be able to take this hydrogen and produce electricity? Why not using the electricity produced in the first place?
There are some local and small scale uses of stored energy where hydrogen could be the agent. There are some very interesting ideas to use fuel cells and recycled gas to form a revolutionary type of large scale "battery" by Prof. Emanuel Peled of Tel-Aviv University. However, so far, nobody proved the practical viability of hydrogen cells as such for any large scale source of energy not even in theory.
The search of ways to use hydrogen as a massive source for electricity is just one type of strange sequences. Not having a real proof that the global warming is due to fuel burning why trying to collect the so called "greenhouse gasses" in large containers and burry them in the ground? Why not enhancing their absorption in new plants? Why not recycling wood? etc.
Notably, expensive methods usually need large amounts of energy for production. Studies have been shown that the production of photovoltaic cell requires an amount of energy that can hardly be produce during their lifetime.

4.8 There are several other sources that are not exactly of the same type

Among them is the use of geothermal sources that can be very useful in some countries. Like in the case of the fruits of the sun we do not have to pay for the source. An Israeli company - "Ormat" installed around the world about 1000 MW geothermal power using especially an Israeli development of a turbine operated by an organic fluid that boils at relatively low temperatures.
The ocean's tide is affected by the moon and can be used in some places by capturing sea water during the high tide and releasing it at a low tide. One ver interesting site is the Red sea. It has atide twice a day and a typcal raqte of flow at the southern entrance reach 40 thousand cybic meters per second. However I am afraid to think what could be the damages involved top the sea.
Finally, nuclear technology can supply energy, but it has its problems of nuclear waste. There exists also a series of security problem and the electricity is not necessarily cheap. It brings with it all kinds of other sensitivities which highly depend on security requirements. Several countries are in the process of gradually closing existing nuclear power stations.

4.9 Conclusion about replacing the use of fuel

In summary, we can replace the use of fuel to a very high extent 50-60% or more (depending on the conditions in each country). This is with economically very attractive known technologies.
A former cabinet decision was to reduce the use of fuel by two percents till the end of 2007. Several years passed and nothing of it was done. A lot can be done in order to move consumers away form the peak of demand and combined with storages.
In the following we shall describe a new technology that uses a new form of the fruits of the sun. This new technology would revolutionize not only the electricity supply, but also eliminate water shortage and replace fuel for transportation.

In view of these it is hard to accept the decision that recently took place by the Israeli government to build a new coal operated power station on the little which was left of the sea beach, and knowing for sure that this station is going to kill hundreds, every year, and cause illness to thousands more. **This unbelievable decision is a demonstration of the worst problem humanity sufers from. It is for some reason not limited to Israel, but rather almost worldwide.**

5. We wish to use methods that would have a positive feedback and as many as possible useful by-products

5.1 Positive feed back

As will be shown, the new method that uses the fruit of the sun is going to use hot and dry air. The mechanical work is obtained by spraying water into this air. The air cools and we get a downdraft. As will be shown the efficiency of turning the latent heat of evaporation to a net mechanical work and generated electricity is a little above one percent. However, we can get an overall global potential of 15-20 times all the electricity consumed today. The cost is very low, even lower than the electricity from power stations run by fuel.

Thus we fulfill most of the rules we stated in the above. We use the fruit of the sun for producing a mechanical work or electrical power; we maintain the very attractive simple rule in section 3.2.8 where the extra cost of the alternative technology –E, is very small, zero or even negative. In other words, there is no better alternative than this renewable source which is also cheaper than any other technology.

We now wish to define another rule. If the air becomes hotter the rate of down draft becomes higher and in the same installation we get more electricity for air conditioning, and for producing desalinated water.

As will be shown the increase of the prevailing air temperature rises by one centigrade the rate of airflow may increase by the order of ten percents and possibly more. It will also depend on the moisture content of the air.

5.2 Useful by-products

As will be shown the new method will have possibly eleven different by product. Thus it is anticipated to have more income that may even pay back the whole electricity cost. It is suggested to the readers to try and find other technologies that have even one by-product. The most exiting discovery is that among these byproducts we find the capability of producing huge volumes of desalinated water at half the cost compared with the best

methods known at preset. The second contribution is the ability to produce almost unlimited amounts of the so called bio-fuels for transportation without hurting the traditional agriculture.

6. A new technology using the fruits of the sun: hot and dry air

6.1 "Energy Towers" - A new revolutionary form of the fruits of the sun

The "Energy Tower" is a technology which was developed in Haifa, at the Technion--Israel Institute of Technology. This technology enables electricity production in arid and warm environments, utilizing the abundance of hot dry air of such climatic zones as a source of potential energy.

According to the analysis of the "Energy Tower" concept, this technology should be the most economically promising, to date, of all renewable technologies which are being developed to produce environmentally clean electricity. An Energy Tower outperforms hydro, solar, wave and wind turbine sourced electricity, in terms of cost per unit, and also in terms of the ability to provide an uninterrupted power supply. Unlike previously designed solar chimneys, which required solar collectors to heat air to generate an updraft, Energy Towers cool warm atmospheric air, and generates a downdraft, which is present 24/7/365. In addition to supplying electricity, Energy Towers also offer further major by-products.

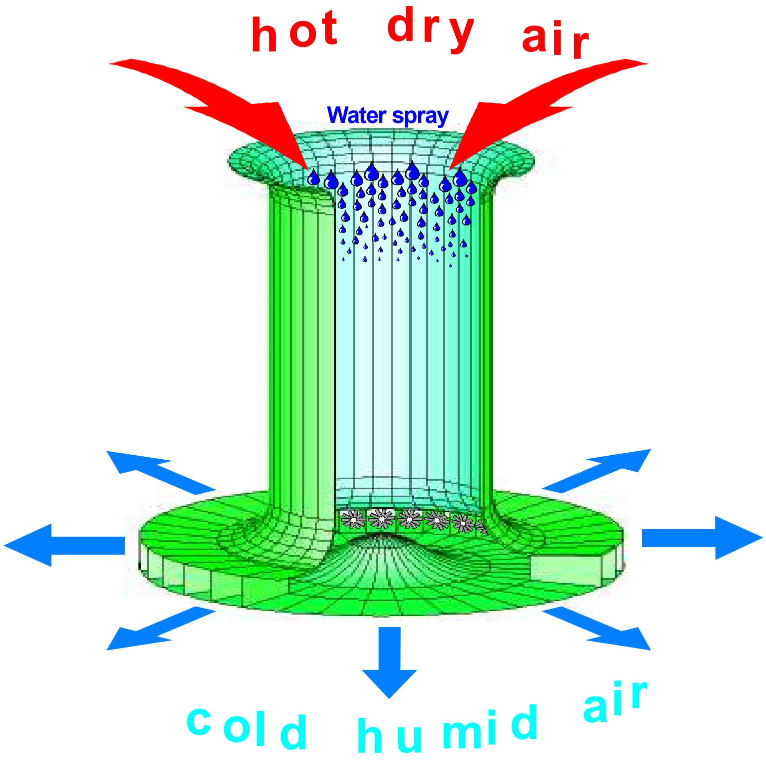


Figure 2 - The Energy Tower principle using sprayed water into hot and dry air and air outlet at the bottom opening motivating turbines.

6.2 The principle of the "Energy Towers"

For this technology to be cost effective the construction of a vertical tube is necessary, with characteristic optimal dimensions of: 1000-1200 m in height, and 400-500 m diameter. (See figures 3 & 4 in the following. The efficiency comes very near to a maximum with Tower's heights, passing about 700 m). Water is pumped up the towers top and sprayed into the shaft. As the water falls, it partially evaporates, and thus cools the air. This cooler air is denser and falls.

In effect, the chimney is a controlled vertical wind making machine. It uses a well known natural phenomenon which is often called "wind shear" and closes it inside a tall cylindrical shaft.

The air in such an Energy Tower can reach high velocities, close to 80 km/h. The kinetic energy developed will reach over 2.7% of the used heat. It will be converted to another mechanical energy, driving turbines at the tower base, which will then convert this energy into electrical energy. A certain part will be used for pumping (about 0.9%) and some will be lost by friction or by throwing kinetic energy outside (about 0.6%). A little above 1.2% will be turned to deliverable electricity. Even at night there is usually sufficient heat in the atmosphere, mainly above some air layer that cools by the cooling ground, enough to allow airflow through the tower. A typical division of the mechanical engineering is given in fig. 5 at a 1200X400 m cylinder, about 40 km North of Eilat, in Israel, and 80 m above the sea level. The efficiency of producing electricity is proportional to the cylinder height. For every 100 m increase in the elevation of the Tower's base, some 5% are subtracted from the net electricity supply.

An *Energy Tower can again be conceptualized as a machine for producing wind on-demand, 24 hours a day, 365 days a year.*

6.3 Proof of the physical principles and the underlying technology

The basic principles utilized by the "Energy Tower" have been repeatedly reviewed by independent consultants and reviewing committees. These reviews have indicated that the physical principles patented by the company called "Sharav Sluices" are feasible, as are the projected economic benefits. An Energy Tower can be built using proven technologies. While a tower of 1200 m in height may seem improbable to some, or at least untested, all engineers consulted with have indicated that the concept lies well within current engineering capabilities found in text books. An 800 m office building which is being under construction is far more complicated.

The development required the use of several independent disciplines. They were all tested theoretically in more than one way and by scale experiments.

6.4 Economy

The Israeli Ministry of Energy nominated an expert review committee to investigate the project. This committee having a wide team of assistants with a wide variety of disciplines, found that an Energy Tower is an economically attractive method of electricity generation. A considerable economic margin is present when electricity from an Energy Tower is compared with electricity generated from conventional fuel sources (coal, oil, nuclear or natural gas). (See tables 3 & 4).

The R & D Department of the Israeli Electric Corporation had participated in the review and confirmed the results, and so did others. Furthermore, this cost-benefit analysis did not include the ecological accounting of externalities, which would further increase the Energy Towers' margin of utility compared to a conventional generation scheme. This estimate also omitted consideration of the by-products such as economical sea water desalination, etc. that further contribute very significantly to the benefit side of "Energy Towers". Finally, the estimate was done before the large hike of fuel costs.

Table 3 - Characteristic electricity production costs (¢/kWh) by major electricity suppliers, for years 2005-2010 (1996 US dollars) (75% load factor, 30 years); costs before the big rise of fuel prices

Replaced technology	**Cost extreme range**		**Representative average costs**	
	5% discount rate	10% discount rate	5% discount rate	10% discount rate
Nuclear	2.47-5.75	3.90-7.96	3.31	5.05
Coal	2.48-5.64	3.74-7.61	4.07	4.99
Gas	2.33-7.91	2.36-8.44	3.98	4.47
Energy Towers	1.68-3.93	2.51-6.42	2.47 (in Eilat)	3.88 (in Eilat)

The first and second column on the left of table 3 show the estimated costs range (Using old dollars value). The bottom line shows the range for Energy Towers. The third and fourth columns show typical average costs of products. At the bottom line again in the Tower in the Arava, North of Eilat.

Another comparison can be made with a somewhat more recent review. Let's take a look at the following table which is taken from: "Contribution of Renewables to Energy Security" , OECD/IEA Information Paper - April 2007 ; written by: Samantha Ölz, Ralph Sims & Nicolai Kirchner.

Table 4 - Energy costs

Technology based on	Investment costs ($ US/kW) in 2005	Electricity generation costs (¢/kWh)
Large hydro	1,500-5,500	3-12
Small hydro < 10 MW	1,800 - 6,800	6-15
Wind onshore	900 - 1,100	3-8
Wind offshore	1,500 - 2,500	7 – 22
Geothermal	1,700 - 5,700	3 – 9
Solar PV	5,000 - 8,000	18 – 54
Solar thermal	2,000 - 2,300	10.5 – 23
Biomass	1,000 - 2,500	3 – 10
Ocean (current, tidal, wave)		5.5 – 16
Coal	1,000 - 1,200	2 – 6
Coal with CCS	1,850 - 2,100	4 – 6
Natural gas	450 – 600	4 – 6
Nuclear	2,000 - 2,500	2.5 - 7.5

It must be stated that the lower limits of solar PV, solar thermal and nuclear are not at all realistic. They are far too low compared with examined data. Hydrogen is not even mentioned as an energy source and rightly so. Furthermore, the estimated investment is per installed kW. The investment to compare with must be per average kW, and is considerably higher. It is easy to show that the practical load factor of supply from photo-voltaic cells is certainly less than 0.3 and, in all probability, closer to 0.1 and this even if the figures in the above table 4 are acceptable, the investment per average kW is between 3 times to 10 times the figure there or between $ 15,000 to $ 80,000.

The same must be said about the solar thermal. The cheapest kWh known from this source was found to be ¢ 15.5. It cannot supply more than one third of the day without the use of fuel. In wind farm seems to be right, however, the average kW cost is three times as much. The calculated investment for an Energy Tower of the dimension of 1200X400m, North of Eilat (40 km from the sea and 80 m above the sea level) was found to be $ 2300 per average KW.

The committee nominated by the Minister of Energy investigated the potential cost benefit of setting up an Energy Tower in the Southern Arava Valley, which runs on a North-South axis between Israel and Jordan. The projected production cost of electricity in this region was found to be 2.47 ¢/kWh at 5% discount rate and 3.88 ¢/kWh with 10% discount rate over 30 years, including operations and maintenance and 4 years construction period. Thus, the electricity costs from an Energy Tower are slightly less than the average electricity costs of oil, coal and natural gas combined cycle power stations with the old prices. When considering the economics of power generation alone, the range of possible costs for conventional power sources widely overlaps those obtained from an Energy Tower. However, as it was stated, electricity generation is not the only direct economic benefit to accrue from

running an Energy Tower. The fringe benefits would vary from site to site and are estimated to range from 4 to 14 ¢/kWh, depending on the situation.

6.5 Few points to compare solar technologies with the "Energy Towers" technology

An Energy Tower's projected cost of electricity production is the lowest of all current renewable sources, with the exception of some very large hydro-power stations under very favorable conditions.

For example, electricity generated from photovoltaic cells costs today is in the order of 30-40 ¢/kWh (old cents) (and not the number quoted in table 4). The most recent suggested price for electricity (July 2008) sold to the network is 57 ¢/kWh. The investment /average kW from photovoltaic is in the order of $50,000. For an Energy Tower in the Arava Valley in Israel, the investment is $2,300/kW - over an order of magnitude less. The projected cost of electricity from the best solar thermal technology by Solel was found to be 15.5 ¢/kWh and the price suggested by the Israeli Government, in July 2008, was 20 cents. The investment in an average effective Kilowatt output that works one third of the day would be way over 15000 dollars.

The investment in a wind turbine is usually over $ 3000/kW average. Again, intermittency is a problem that limits the use of wind-turbine generated power as an overall renewable solution. For a continuous supply, one must add an alternative source or a storage system.

An Energy Tower is an additional source of energy that is obtained indirectly from solar radiation, similar to wind, hydro and bio-mass, rather than directly the solar radiation.

Another interesting comparison is that of the land area needed to produce 1,000,000 kWh/year. The area needed with the Energy Towers is not more than 250 m^2/1,000,000 kWh/year for the main structure. It does not exceed 750 m^2 when we include some of the by-products and extra safety in collecting the salt spay. Without it the needed area is only one third and the diameter is not more than one kilometer. The area needed for the best solar technology today is 6000 square meters, 8 to 24 times respectively. For the full area or only the main structure. The area needed to produce 1,000,000 kWh/year with the updraft solar tower is about 300 times larger.

Some more economical data are given in sections 6.9 and 6.10.

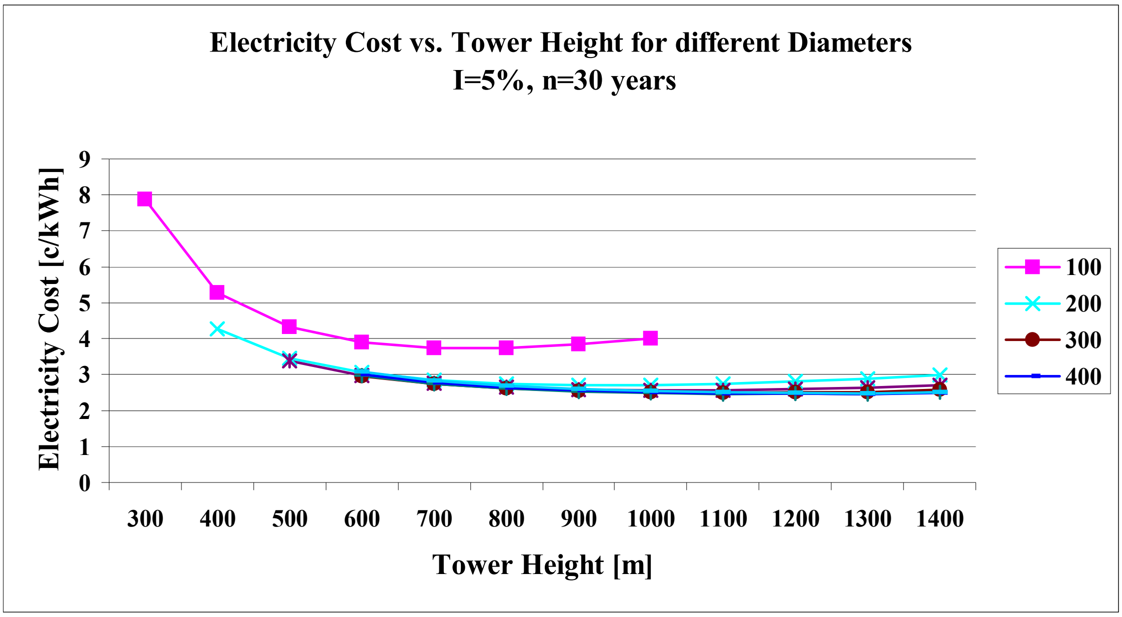


Figure 3 - Electricity production cost from Energy Towers with 5% discount rate, in the Arava Valley in Israel (see data below for the diagram with 10% interest rate)

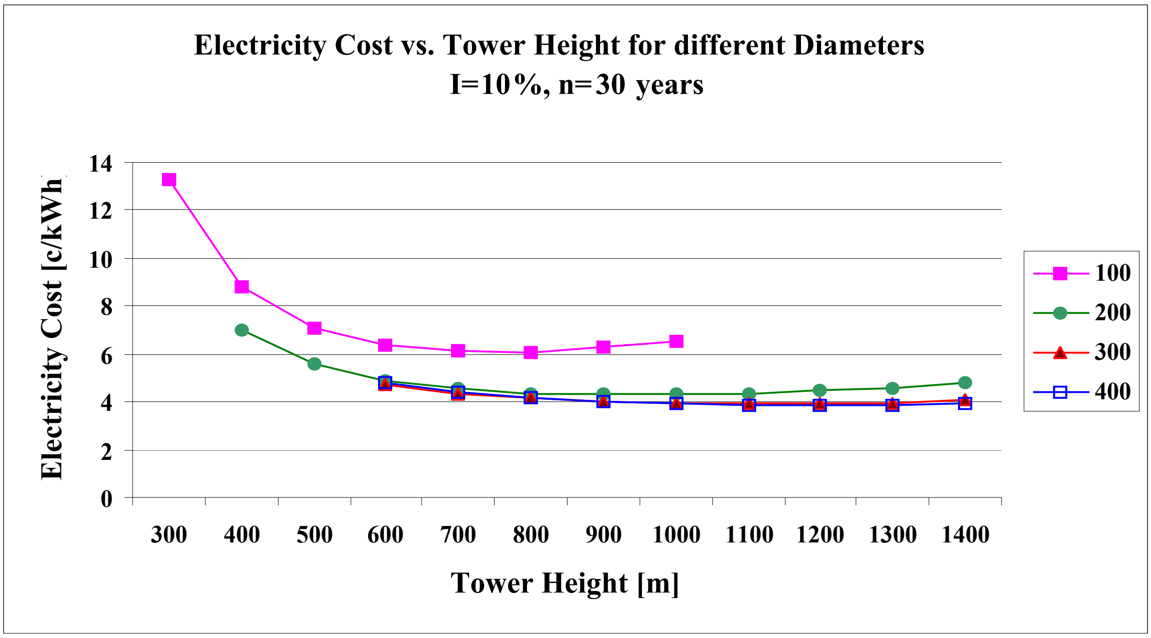


Figure 4 - Electricity production cost at the energy tower with different height of the shaft and different diamet4rs. Assuming 30 years life, 4 years construction at 9% during construction and 0.56 cents per kWh operations and maintenance, A tower 40 kilometers north of Eilat, 80 meters above sea level an 1200x400 meters shaft dimensions. Estimated average output 370 megawatts or 3.1 billion kWh per year deliverable

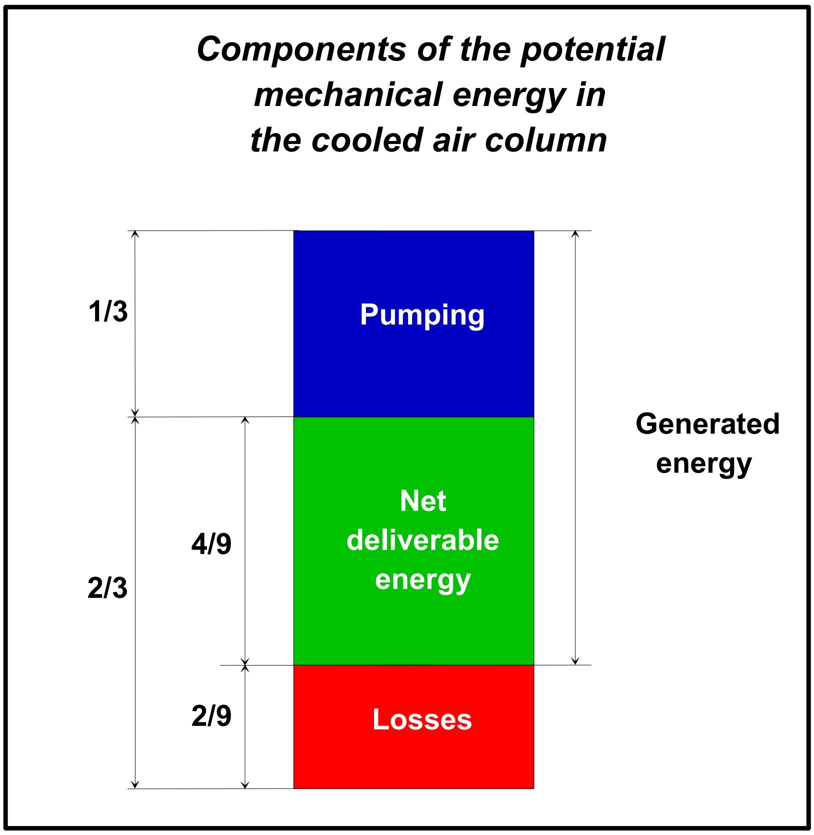


Figure 5 - Components of the mechanical energy (North of Eilat)

The basic limitation on the energy tower is that the pumping part will be less than the total mechanical energy that the down draft air flow produces. If there is some energy left unspent, then we can design the whole system in such away that the losses will be exactly one third of what is left over after the pumping.

6.6 The potential of Energy Towers

At the above cited cost, the potential for power generation using Energy Towers in Israel has been analyzed and found to be more than twice Israel's projected future energy consumption. The cost per unit is calculated to remain cheaper than electricity produced from fossil fuels (see figure 6).

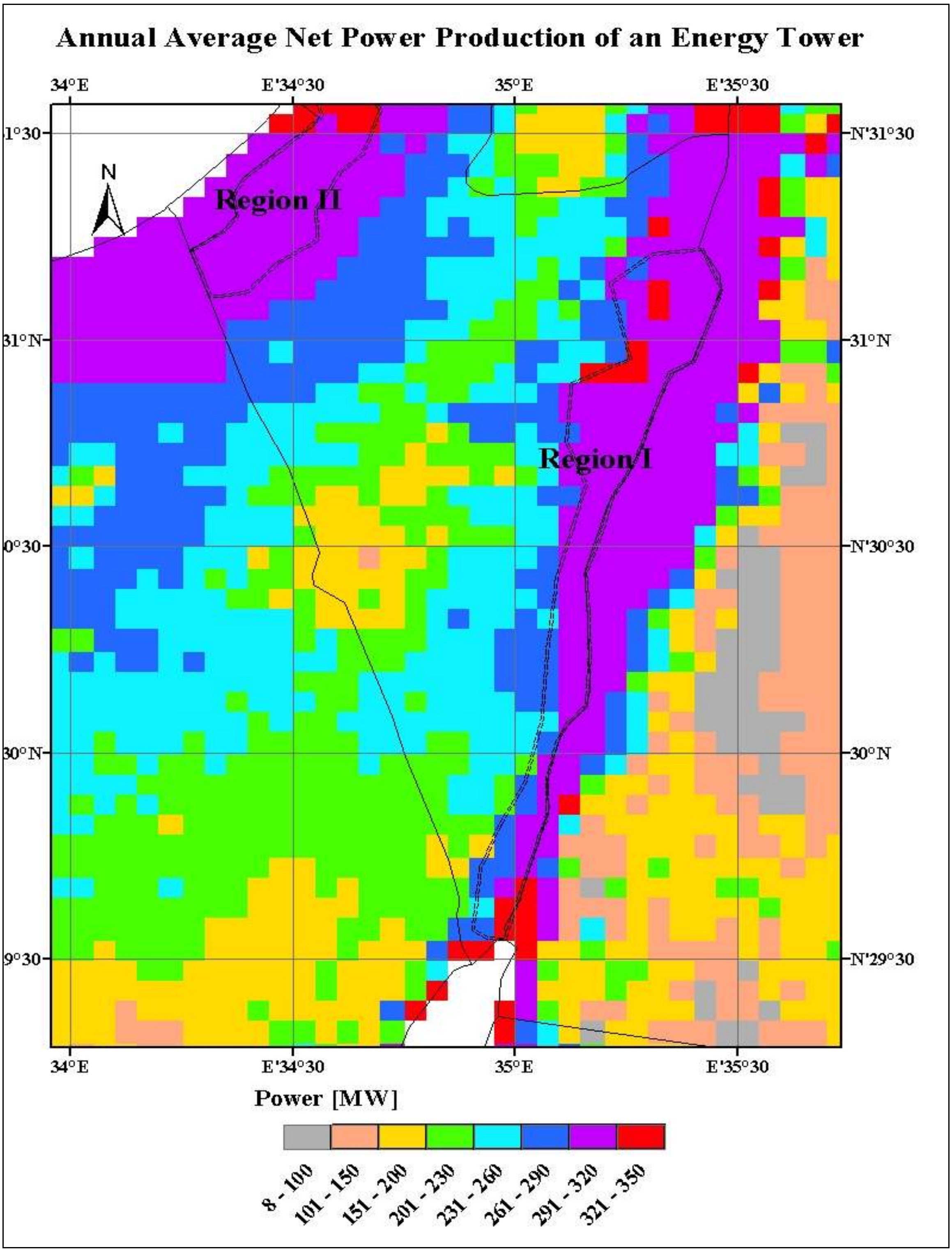


Figure 6 - Mapping of the net output from a standard design Tower in the South of Israel (5x5 km area units)

The theoretical global potential of Energy Towers was recently calculated, as an academic exercise, and under very conservative assumptions. A net average output per Tower was conservatively assumed to range from between 200 and 600 MW average output. Areas where the climate and topographic conditions lead to an output lower than 200 MW average were excluded from the survey. The minimal diameter of sky space was assumed to be 400 km^2 per Tower (so that sufficient descending hot air is available for each Tower).

The global potential power generation using Energy Towers was conservatively estimated to be 230,000 billion kWh/year. This figure assumes an electricity production cost for the Tower not higher than 3.93 ¢/kWh, or 6.42 ¢/kWh at 5% and 10% interest rates, respectively. This mapped global potential is at least 15 times the present electricity global consumption. The climatic data was obtained from satellite global mapping. Concrete distances from the sea and elevation differences were used for the calculation. A very similar result was obtained by estimating the heat transfer by the Hadley Cell Circulation from the equatorial zone to the two desert belts around the globe to be 2-4X10^{16} KWh/year. (The maximum estimate was an order of magnitude higher). The efficiency of turning it into electricity was assumed to be 1%. The result was then 200,000 to 400,000 billion kWh/year.

In the following pages you'll see table 5 for global Towers population by size and a table of the possible regional energy supply and the possible number of people served.

Figures 6 and 7 show typical maps of the South of Israel and a small part of the Middle East. Figure 8 shows the schematic Hadley Cell Circulation, the gross heat transfer and the power potential computation assuming 1.2% efficiency of heat to deliverable electricity.

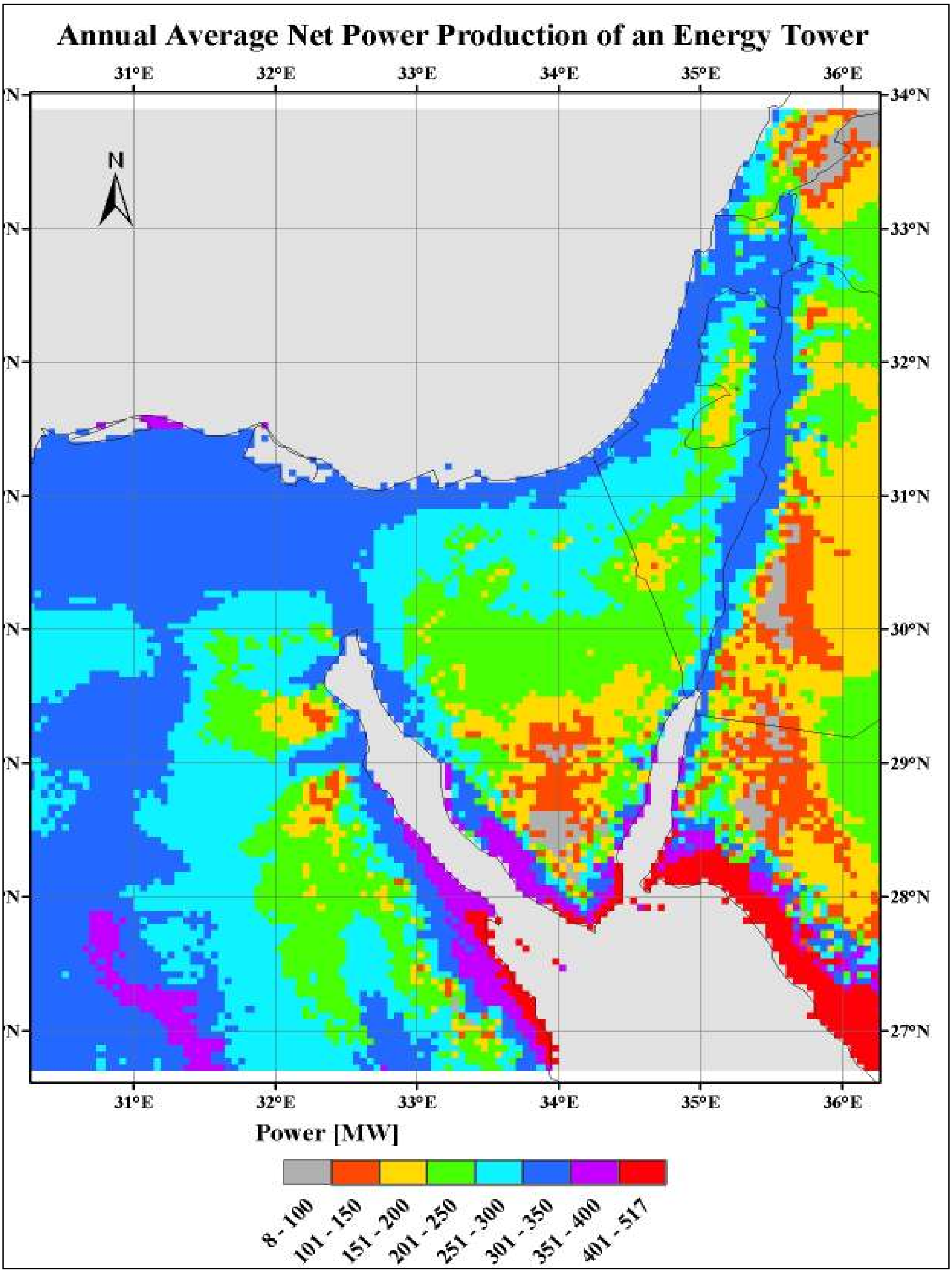
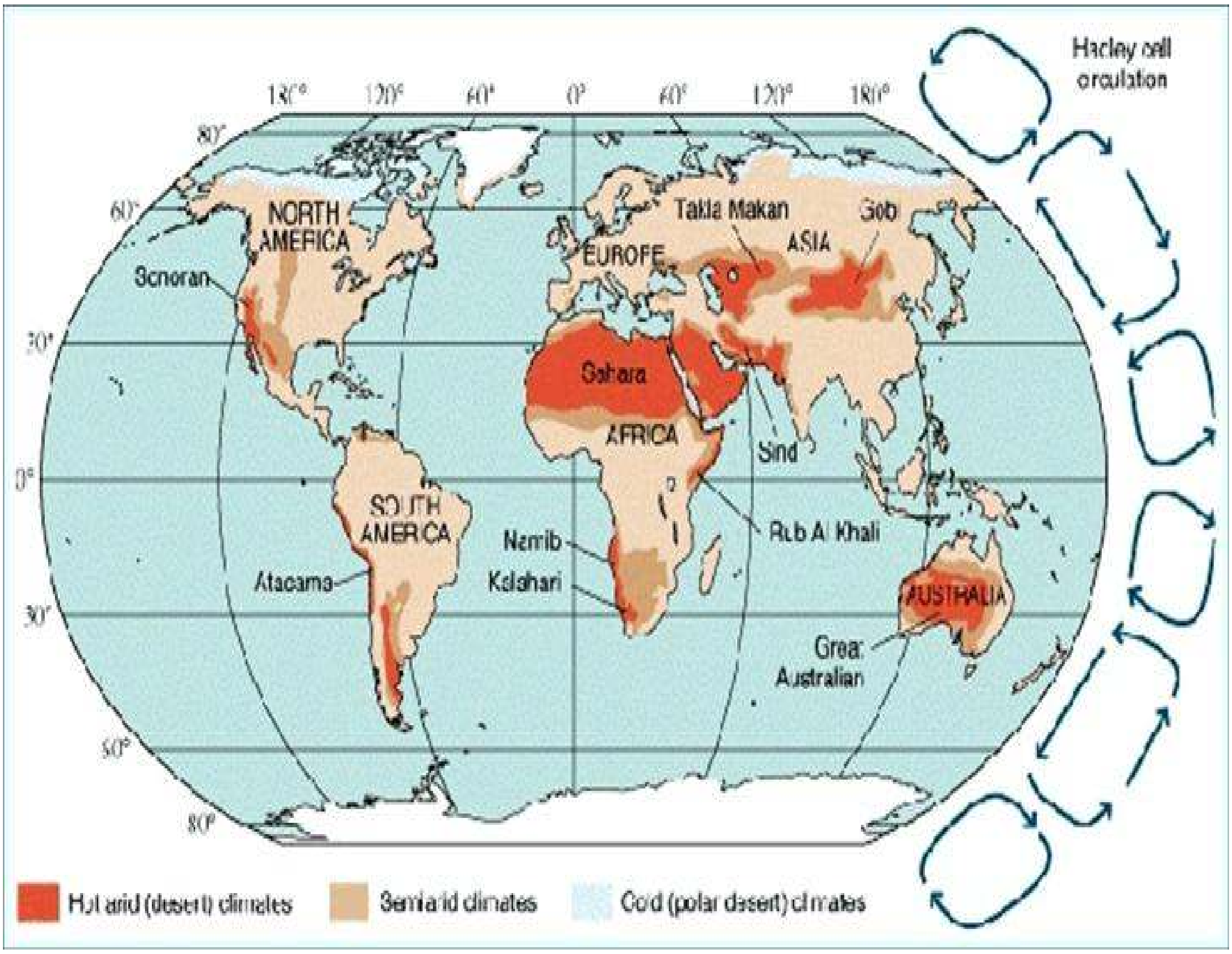


Figure 7 - Mapping of the net output from a standard design Tower in Israel and its neighbors (5x5 km area units)



Heat $2*10^{16}$ - $4*10^{16}$ $\frac{\text{kWh}}{\text{year}}$

Electricity with 1.2% efficiency $2.4*10^{14}$ - $4.8*10^{14}$ $\frac{\text{kWh}}{\text{year}}$

Figure 8 - The Hadley Cell Circulation with two arid belts

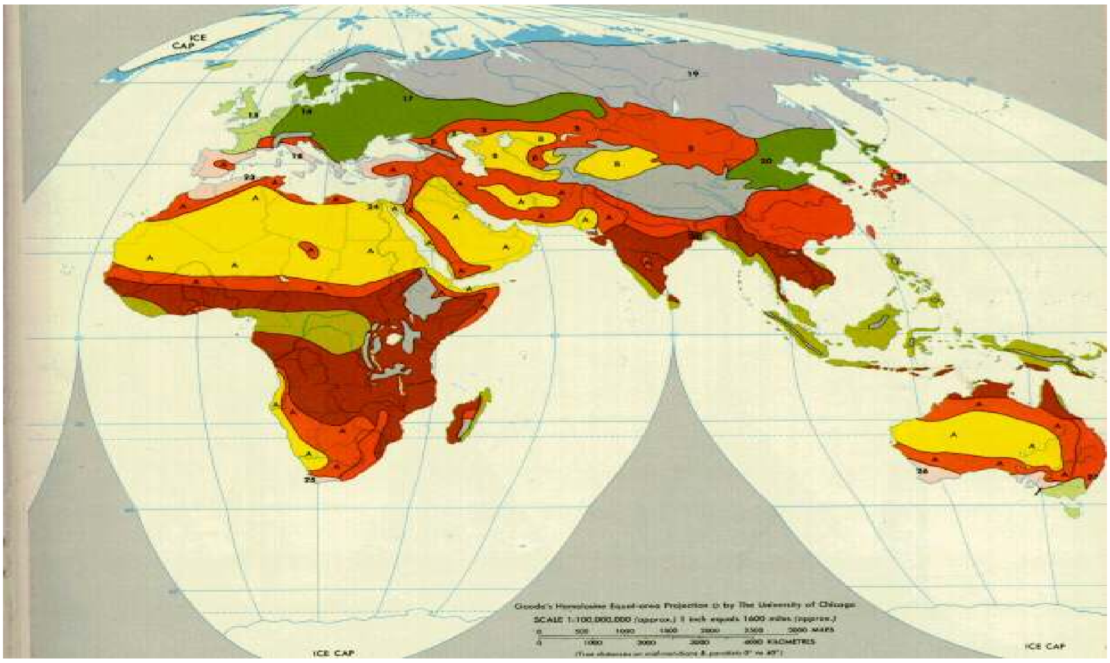


Figure 9a - Climatic zones in Europe, Asia, Africa and Australia. The yellow and bright red areas marked by the letter "A" are desert or arid lands

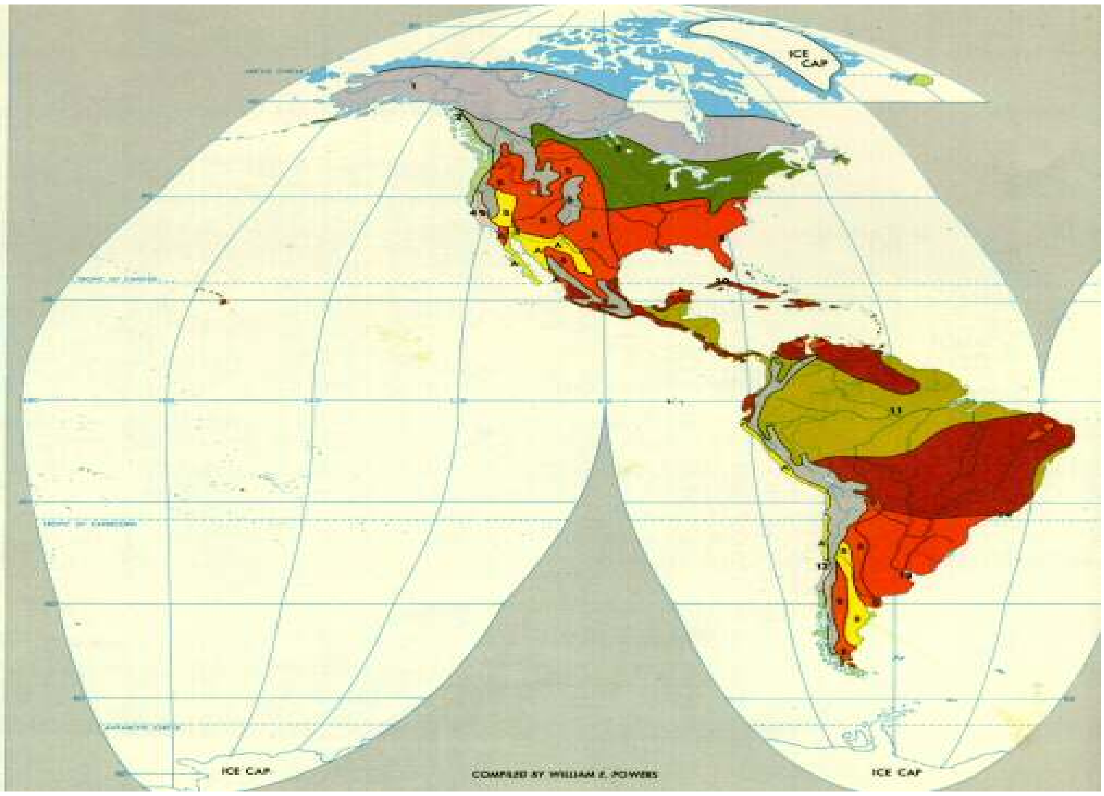


Figure 9b - Climatic zones in America. The yellow and bright red areas marked by the letter "A" are desert or arid land

Table 5 - The average net power range [MW] from Energy Towers and the total area (thousand of square kilometers) in the world for each range

Average net power (1)	**Area (2)**	**Number of required Energy Towers (3)**	**Annual energy for this area (4)**	**Electricity cost (5% discount rate) (5)**	**Electricity cost (10% discount rate) (6)**
[MW]	*[10^3 km^2]*	*[-]*	*[10^9kWh/year]*	*[c/kWh]*	*[c/kWh]*
550-600	69	173	839	1.68-1.78	2.51-2.69
500-550	233	583	2,679	1.78-1.90	2.69-2.90
450-500	1,017	2,542	10,579	1.90-2.05	2.90- 3.16
400-450	2,248	5,620	20,923	2.05-2.24	3.16 - 3.49
350-400	4,167	10,418	34,221	2.24-2.48	3.49-3.91
300-350	5,989	14,973	42,627	2.48-2.80	3.91- 4.47
250-300	8,597	21,492	51,775	2.80-3.25	4.47- 5.25
200-250	13,137	32,843	64,733	3.25-3.93	5.25-6.42
Total	**35,457**	**88,644**	**228,376**		

The number of towers is conservatively calculated assuming a minimum sky space for each tower to be 400 square kilometers.

Table 6 - Regional potential from the Towers producing more than 200 or 300 MW average

Region	**Number of people served with Towers better than 300 MW**	**Number of people served with Towers better than 200 MW**	**Electricity per capita per year**
	[billions]	[billions]	[kWh/year]
North Africa	3.58	7.73	6,000
South Africa	1.37	2.79	6,000
India	1.19	2.68	6,000
U.S.A., Canada & Mexico	1.22	2.72	10,000
Chile & Peru	2.77	3.94	6,000
South Europe	0	0.55	6,000
Australia	0.71	1.96	6,000
Saudi Arabia	1.25	1.46	6,000
Persian Gulf	1.12	1.15	6,000
TOTAL	**13.21**	**24.98**	**------**

Adding the Towers with an average output from 200 MW to 300 MW actually doubles the number of people that could be served. Though it is not uniformly correct in all the regions.

The area in North Africa that could be installed with at least 300 MW and up could supply 3.58 billion people electricity at a European consumption level. Allowing 200 average MW will enable electricity supply to nearly 8 billion people. At the same time, cheap sea water desalination could provide water at volumes nearly 15 times that of the River Nile, just by using 20% of the electricity (not less than 400 m^3 per capita per year).

Energy Towers at the Southern part of Europe have relatively poorer climatic conditions. Over half billion people can still be provided with electricity at somewhat higher production costs, but with lower transmission costs, and certainly less than the cost of solar thermal and photovoltaic which now is a subject for spending billions of dollars government support. We could choose the optimal combination. The electricity produced in California and Mexico could serve at least 1.2 billion people at this low rate of 4.5 ¢/kWh or less at the power station gate, extending the use down to 200 MW average power Towers, the supply could be sufficient for 2.7 billion people.

It might be of interest to Iran that using the technology of "Energy Towers" they could, in all probability, supply to 400 million people electricity at a Western European level and they could have very cheap desalinated water at the amount equivalent to twice the Nile River by using just 20% of the electricity. This alternative should be passed to them to replace their nuclear "games". Moreover, it is far more attractive than the nuclear energy offered by some from any point of view, except for devoted terrorism.

6.7 Additional benefits of the "Energy Towers"

There are nearly 20 additional benefits that devolve from the installation of an Energy Tower. About half of these are tangible-material by-products; the other benefits are of an intangible macro-economic environmental or political and strategic nature. Our conceptual approach was first of all to look for the fruits of the sun rather than the radiation itself. The "Energy Towers" technology did it and very well. We were also looking for possible by-products as a matter of principle and possible positive feedbacks to adapt to unpredictable changes. And to our great surprise, here we are beyond our expectations.

1. Adaptation of supply to demand by pumped storage There are time fluctuations in the electricity production and fluctuations in the demand. There are several ways to overcome these discrepancies.

The first one is built-in pumped storage. Observing fig. 5 in section 6.5 above, one can see that in the example in North of Eilat, the pumping energy makes about 3/9 and the electricity supply 4/9 of the

overall mechanical energy. This means that if we temporarily stop the pumping, we can add about 75% to the electricity delivery. All that is needed is water storage at a high enough elevation.

It is a built-in capacity with no energy loss and minimal additional investment. It will improve the economics of an Energy Tower by more than 30% (in the order of 2 ¢/kWh over and above the average tariff that can be obtained in many sites).

If one does not find a nearby elevated ground, then it is possible to build a reservoir on the top of the Tower if we turn from a steel structure to a reinforced concrete.

One can adjust the installed capacity.

2. adaptation by adjusting the designed capacity. By lowering the installed capacity we loose some energy at the peaks in the summer. However, we reduce the investment in the active parts which make about 2/3 of the overall investment. The cost of the structure does not change. At the extreme, we can get a fixed deliverable output throughout the year. This is with about 25% increased electricity cost.

3. Adaptation by some time variable product. Another way of adaptation to fluctuations can be achieved by using electricity for a certain product, such as desalination, and stop it periodically.

An optimal design should be looked for in each case.

4. Desalination

Desalination of sea water / brackish water / sewerage waste water can be incorporated. There are two very fundamental advantages in this incorporation. First of all we make sure that electricity will be available and that its cost rise will not lead to more than doubling the water cost. Second, the combination allows us to cut the cost to one half.

The capacity can be added in a modular fashion.

In an actual analysis it has been found that the projected investment saving for desalination using this technology, Reverse Osmosis in association with the "Energy Towers" technology, is over 50% and the energy outlay is 33% less when compared to conventional Reverse Osmosis. The cost savings for sea water desalination was calculated to reach 45%, when contrasted with current methodologies.

Utilizing 20% of the Tower's energy, calculated according to base line dimensions, it is possible to desalinate 200 million m^3 water/year. As the electricity from such a Tower North of Eilat is sufficient for half a million people at a West European standard (3.1 X 10^9 kWh/year at 6000 kWh per capita per year). This means additional water of about 400 m^3/capita/year comparing to only 300 m^3/capita/year today in Israel.

By some optimization we may reduce the cost below 25 ¢/m^3. This is a major benefit - indeed, it is conceivable that an Energy Tower might one day be built for the sole purpose of desalination - allowing human habitation of previously unviable desert regions. At this cost per cubic meter, water is cheap enough for industrial applications, and for a broad range of agricultural applications including food production and fuel supply through bio-mass.

5. **Replacing fuel for transportation**

Having huge volumes of cheap desalinated water in huge desert areas, we can provide for irrigating oil plants. The extracted oil can replace diesel fuel. Other plants and agricultural waste can be used to produce Ethanol to replace gasoline and bio-gas to replace natural gas. Can we imagine North Africa providing electricity to the whole of Europe (see table 6 above), and also having for its own use both electricity and fuel for transportation? At the same time, North Africa will have water addition like 20 times the Nile River.

6. Aquaculture By using the water en-route to the Tower, each Tower of standard design has the potential to provide facilities for the production of 160,000 tons of sea fish per year. All it takes is to retain the sea water on-route to the Tower for a day or two. The total water spray North of Eilat was calculated to be 600 million cubic meters per year. One day average retainment means about 1.6 X 10^6 m^3 of ponds. Experience shows that about 100 kg fish could be grown per 1 m^3 of pond, or the figure of 160,000 tons. The limiting factors in growing sea fish in ponds were lack of area near the sea coast and the need to pump sea water to high elevation and distance. Here we get these for free.

This would provide income that is well above the cost of water supply to the Tower and would eliminate the environmental pollution problems associated with sea-based aquaculture or at least reduce it considerably.

Aquaculture could add nearly another cent per kWh profit to the added area for ponds that could surround the Tower and will add no more than 500 m^2 per million kWh per year, totaling about 750 m^2 per one million kWh per year. Fish growing could easily provide another cent additional profit.

Note that 1 kg fish requires only about 1 kg dry food. This compares to 2 kg for poultry, 3 kg for hog meat and 5kg for cattle. Thus, fish farming makes possible providing meat to the population and saving a lot of land and water.

The potential has been estimated to be possibly twice - 130 million tons per year, and this is compared with present value of 90 million tons from both sea fishing and ponds at present.

The first two benefits of running an Energy Tower are expected to range from between 2 and 3 ¢/kWh in all or most sites. We have not estimated the benefit of producing fuel for transportation.

By the way, some argue that cattle gas emission makes a large share of the greenhouse gases. So, replacing their meat by fish, is another good contribution.

7. Salinity elimination Salinization is presently destroying some of the largest irrigation projects and is affecting irrigated agricultural land in many locations world-wide. The drainage water, left after irrigation accumulates salts, eventually turns ground water and rivers more and more salty. Using the collected drainage water to produce electricity in an Energy Tower, produces a more concentrated brine that is much cheaper to dispose. The overall result is that the expensive disposal of the salty drainage water is reduced to about 5%. An additional benefit of 10 kWh electricity is produced for each cubic meter of evaporated water in the Energy Tower. Studying the Indira Gandhi Canal which is in the north part of India. (Rajasthan district). It has been found that about six Energy Towers could

be built disposing of about 3.5 billion cubic meters of brackish water, producing in the order of 30 billion kWh per year. it has also been found that for the interception of one cubic meter of brackish water, half a cubic meter of fresh water could be gained towards the Canal end closer to the sea. This is by removal of salinity from the main water stream.

Since much av

ailable surface water on earth is brackish, there are other benefits in water aquifers, or drainage water. This water can be used to produce electricity, desalinated and the brine can be pumped into the ocean, producing approximately 10 kWh for each cubic meter of evaporated water.

This is the second by-product which solves water problems (following item 2).

8. Energy recovery. From the end brine, having twice the salinity of sea water and from the sea water itself - it is possible to recover a significant amount of energy (close to 10% addition). Much work is being done in Northern Europe.

9. Cooling water for thermal stations, including solar thermal We can build thermal power stations without the need to occupy more sea coasts.

10. Air cooling for gas turbines Cooling the air by one centigrade improves the turbine efficiency by about 1%. In reality, the air cools about 10 centigrade.

11. Positive feedback is obtained This is because as the prevailing air is warmer, the difference between the outside air and the cooled air density difference between the inside and the outside becomes bigger. Assuming that there is no independent increase in humidity, then the motive force becomes stronger. The energy output from the Energy Tower then increases.

12. Improved cooling mechanism of the warming globe The explanation of this by product is beyond the scope of this report. Research is needed still to know the real extent of this process which Is caused basically by humidifying the air near the ground at the equatorial belt and causing a wet adiabat cooling with height rather than dry adiabat (about half a centigrade for every hundred meters rather than a whole centigrade) in the Hadley Cell Circulation. The largest extent of cooling is from the upper air above this belt, where the water freezes, but the air can most easily radiate the heat out.

These are the main material tangible by-products. Some of the others are:

13 Zero-emission electricity generation At least we shall not have to pay penalty in accordance with the Kyoto Protocol.

14. Avoidance of reliance on imported fuel This not only from Middle East oil suppliers. It is also from Russia and from Venezuela who equally use their fuel resources for black mailing power

14. Immunity from future fuel price instability and the inevitable cost rises

16. Immunity from cost fluctuations (see section 3.2.5)

17. No need for costly strategic fuel reserves.

18. Improved balance of payments both by saving and by industrialization

19. The use of clean zero-emission renewable energy will avoid the penalty of greenhouse gas emissions (the Kyoto Protocol) and might be materialized into some income.

20. Potential benefits, savings on defense costs and alleviating the blackmailing capacity by oil merchants

6.8 Overall important gains

Energy Towers could turn out to be the democratic world's most effective weapon with which to maintain political freedom and to prevent irreversible environmental degradation of the planet. Energy Tower technology addresses the following global problems:

1. **Eliminating pollution and greenhouse gas emissions due to fuel burning both for electricity and for transportation (regardless how unreal is the story about it).**
2. **Supply of clean fuel for transportation at reasonable cost.**
3. **Governing the shortage of good water, over pumping and salination of agricultural land.**
4. **Preservation of marine ecosystems, by encouraging sustainable aquaculture.**
5. **Avoiding wars, reducing military spending.**
6. **A major political change and more equitable distribution of richness among nations.**
7. **Having a positive feedback to climatic changes of the globe.**

6.9 Performance compared between the Energy Towers and other leading subjects for public spending

Table 7 - Comparative performance of different technologies for producing massive electricity

	Energy Towers	**Best solar thermal**	**Best photovoltaic**	**Hydroelectric**	**Wind**
Production cost [¢/kWh]	2-6	20	40-50	At least 3	At least 4
Working hours per 24 hours	Unlimited	6-8	6-8	Unlimited	Intermittent and irregular
Global potential of electricity use	15-20 times the global present use	Unlimited	Unlimited	Only 7% of global use	10-20% of global use
Needed area in m^2 per million kWh per year	With no by-products - 250; With by-products - 700	> 6000	> 6000	Very large	Partial use, but very large
By-product	9-10	None	Thermal	2	None
Added value in cents per kWh	4-14	0	About 2	Low	0

Following are two diagrams - figure 10 and 11. One shows the Internal Rate of Return (I.R.R.) at 10% interest rate before tax. It is anticipated that the income per kWh would be at least 10-12 ¢. The I.R.R. is then at least 20-25%. The other diagram shows the return period under the same conditions - it is not more than 4-5 years.

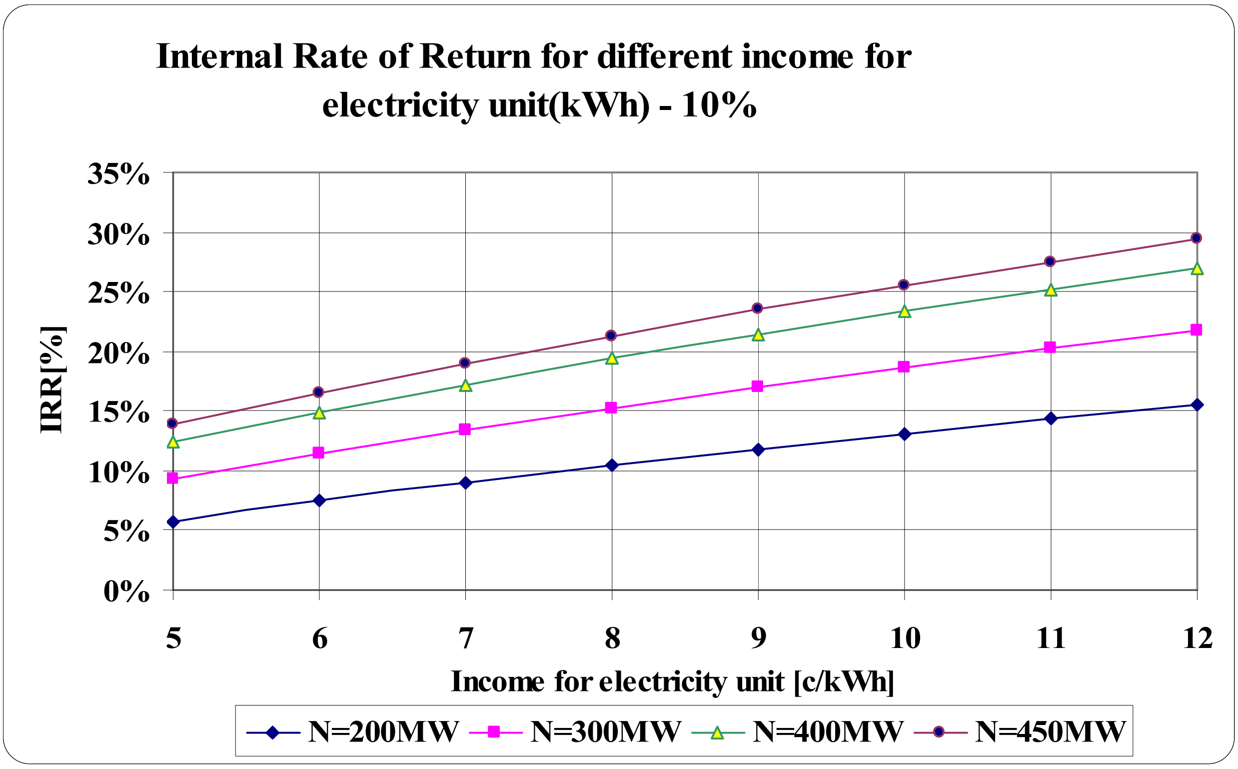


Figure 10 - Internal Rate of Return for Energy Towers - 10%

851 million dollars initial investment under the conditions of South Arava; 4 years construction; 30 years life project; 0.556 ¢/kWh

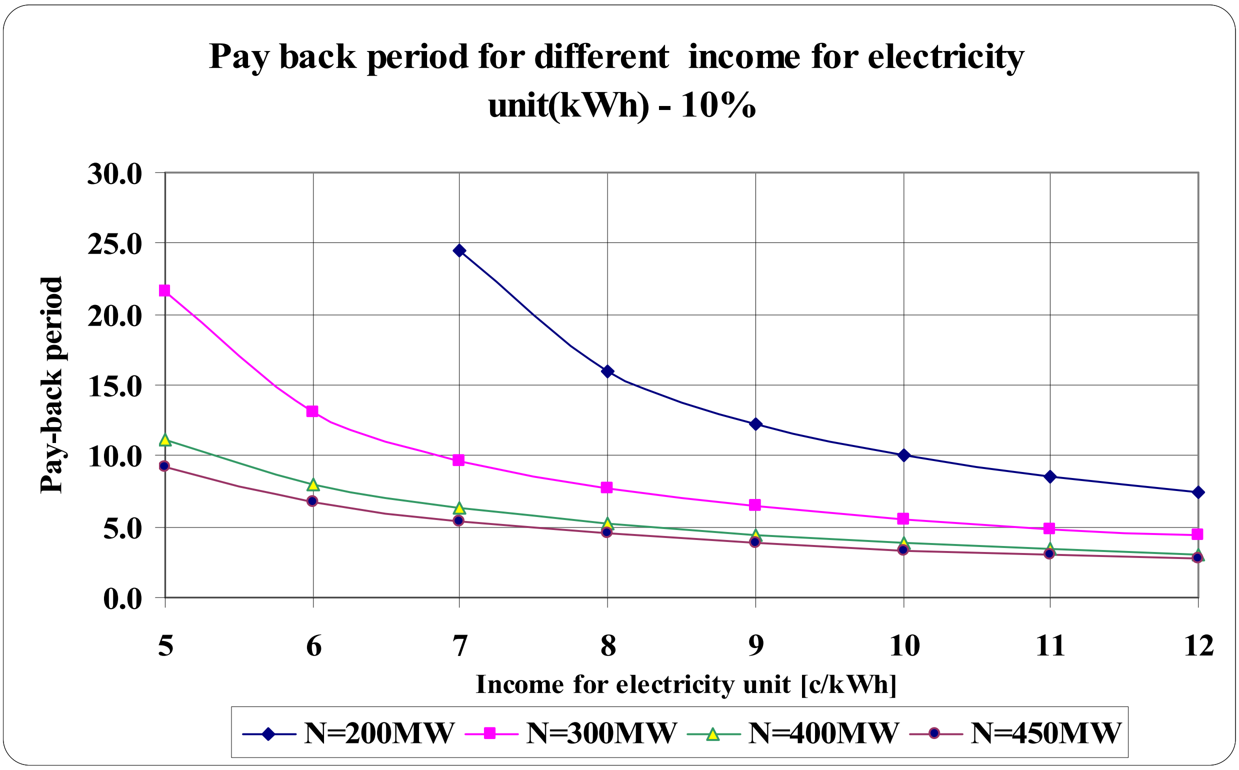


Figure 11 - The pay back period as a function of the income per kWh (i=10%)

6.10 Final notes

It seems that the "Energy Towers" technology is today by far the most attractive method to supply most of the global need for electricity and indirectly by producing very cheap desalinated sea water and replacements for fuels for transportation. In Israel, these two consist of 2/3 of all the energy consumption. The other third is heat that can be obtained directly from solar radiation, or indirectly from the first two. These come along with extremely attractive and revolutionary by-products. The technology can be applied with no delay.

There are three conditions:

I - People who make decisions and provide the means should understand what they are talking about;

II - The so called "experts" should be honest and describe truthfully the real conditions, not being afraid to loose their status;

III - There are people who become insulted by the fact that someone else made a suggestion they did not think about. These people should be kept away from positions of public making decisions or as advisors.

7. What is needed for sustainable and cheap water supply

7.1 The major components of the rain

There are several major components in characterizing the water supply system.

(1) Rain that wets the top soil and evaporates back every season (in Israel about 80%of the average rain).

(2) When a certain quantity of rain infiltrate into the soil, at some points under concave shaped surface of the landscape, water accumulates gradually and at some point saturate locally in the under surface piece of soil. This water starts flowing out of the soil up to the surface and form runoff and erosive processes due to this piping mechanism. The equation involved is very closely as follows.

$$totalrunnoff = P(P-270)1.905x10^{-4}.$$

Total runoff in millimeters=total rain in Millimeters (total rain - 270 millimeters) x s

S =0.00019 (1/milimeters)

- The specific number of 270 millimeters of rain as a threshold is characteristic to the western slopes of the land of Israel from Judea and Samaria to the Mediterranean Sea.

- The first important point is that contrary to what is written in most of the books the rate of runoff is not necessarily proportional to the rain intensity bur rather the cumulative quantity.
- The second important point is that the rate of water percolation which is enriching the ground water looks like the above equation but having about three times the above coefficient, for example 0.00057.
- This leads to a very meaningful table showing the effect of higher or lower rain on the amount of available water stored in the ground or captured in flood reservoirs in a given season. The figures are fit more or less to the western slopes in Israel.

The result is that the runoff in the west part of Israel is about 5% of the rain and the rate of ground and lake recharge is about 15% of the rain volume. See fig. 12 and table 8.

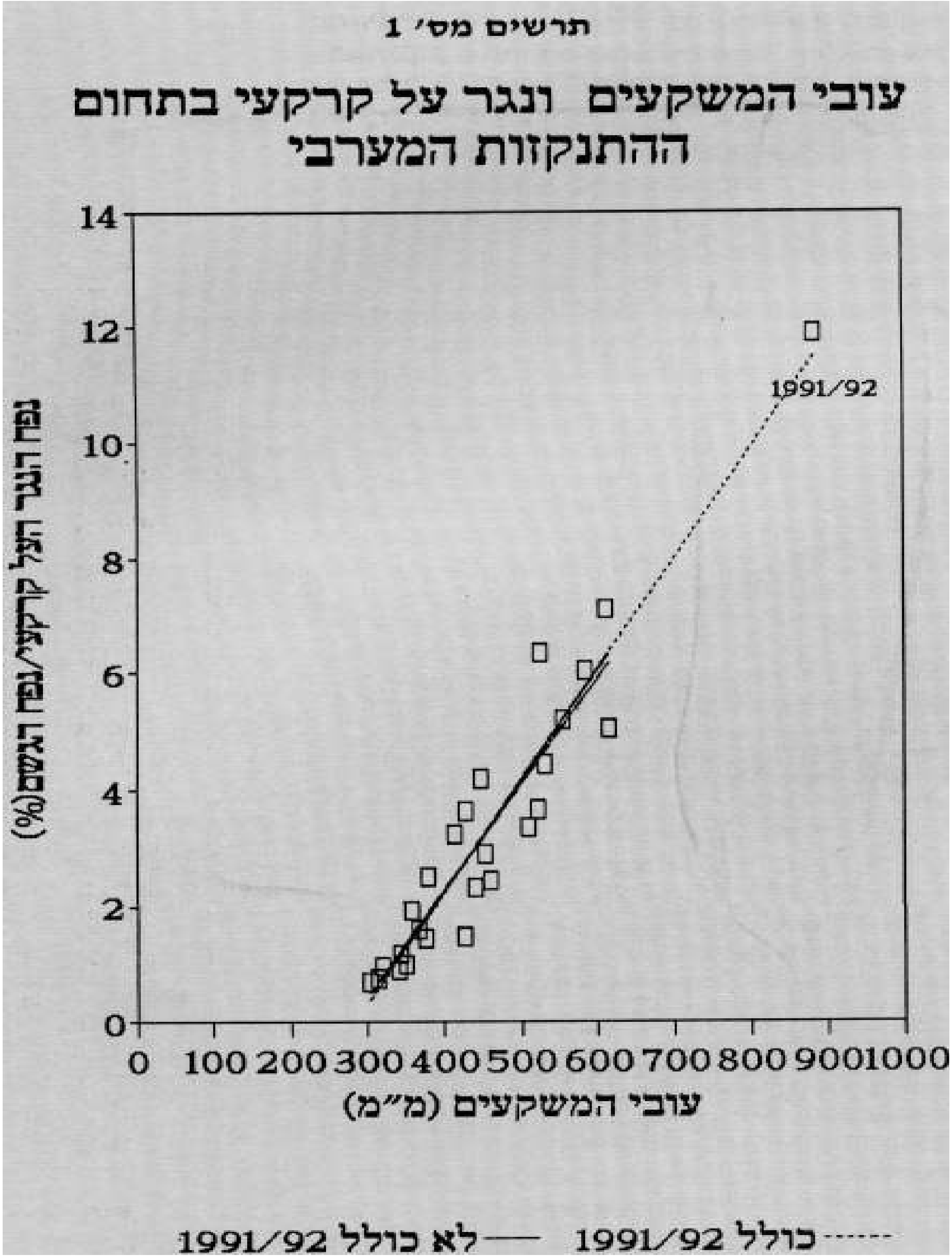


Figure 12 - Percent runoff out of the total rain as a function of the total rain in millimeters (see the formula in the next chapter)

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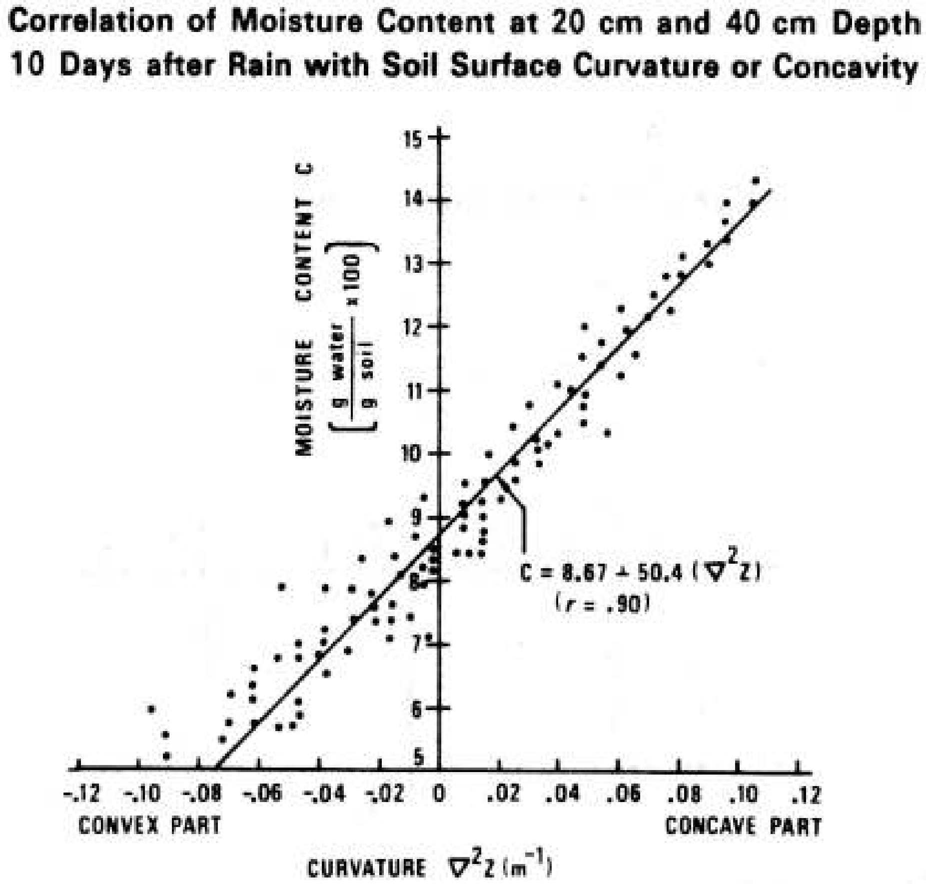

Figure 13 - The soil moisture measured in a field as a function of the laplasian of the soil surface elevation Z with partial derivatives with respect to the map coordinates x and y

Table 8 - Relative chain in the runoff and in ground water addition with respect to the average values as related to the added rain or reduced rain with respect to the average for the east coast of the Mediterranean Sea

Seasonal rain [mm]	Seasonal rain [%]	Seasonal runoff [mm]	Seasonal runoff [%]	Seasonal recharge [mm]	Seasonal recharge [%]
689	+30%	54.9	+106	164.7	+106
636	+20%	45.4	+70.7	136	+70.7
583	+10%	34.8	+30.8	104.4	+30.8
530	+-0%	26.6	+-0%	79.8	+- 0%
447	- 10%	18.8	- 29.3	56.4	-29.3
424	-20%	12.4	- 53	37.2	-53
371	-30%	7.1	-73.3	21.3	-73.3

This is a very meaningful table. For example last winter the rain was 60% of the annual average. This means a reduction in rain volume of 40% but a reduction in the seasonal water storage of 80%.

(3) Addition of rain could easily be up to 30% if we shall complete a technology of mixing the sea water to warm up the sea. This leads to an addition of over 100% to the annual ground water storage, a much better smoothening of the supply curve. We wish the rain amplitude rise well above the average consumption line so that the winter excess will easily compensate for the summer extra use. (This fascinating technology is briefly described in the following).

(4) We must protect the aquifers from pollution so that maximum aquifer volume remains usable.

(5) We wish to be able to produce desalinated water at a relatively low cost, not only in order to add amounts of usable water but even just in order to replace less reliable water resources with reliable ones.

(6) Future global changes that will lower the ocean surface level may also reduce the amount of reserve storage, The very increase of water consumption may call to store winter water for the summer. This should shed some thinking on preserving sites for large water storage. I was personally involved in the master planning of a new city drainage. The land owners were convinced that a relatively wide dip around a river touching the city area should be preserved for flood control, water storage and landscaping. The authorities said they do not have time to spend on this low priority subject. Today those who are still alive throw the blame on others but every one left is sorry and we pay far more than the value of the land. Future design must be done with an overall wide looking with highly diversified disciplines.

It is worth noting that some acts that may seem to be water saving means, in reality effect the overall cost of water use, and not necessarily add water. As an example, over irrigation and water leakage back into the aquifers may add to the cost.

7.2 Added rain

The addition of rain was obtained in the past by cloud seedling. The idea was to help the condensation of vapors on seedling nuclei. However, there is one very different idea how to do it. The idea was suggested by Dr. Gad Asaf and associates. (Gad received his doctorate from the Weizmann Institute, in Rehovot. Large part of his work was done when he worked in "Ormat" in Yavneh).

- They first showed a perfect correlation between the temperature difference measured between the warm sea and the cold air body coming in and the resulting amount of rain.
- Next they have shown a relatively high correlation between the temperature of the sea water at a certain stage in the fall and the rain quantity in the following winter (about 60% statistical correlation).
- The next thing was to show that the amount of rain in a certain event was perfectly related to the heat drained out of the sea at this event and of course for the winter as a whole.
- The next idea was that warming the sea (at least in the eastern part of the Mediterranean Sea) would lead to increased amounts of rain.

The correlation was done in view of learning what is the mechanism of rain production.
There have been several ideas how to warm the sea. Basically, it was supposed to be done by mixing it during the summer so that more heat will be stored and less radiated or evaporated out without contributing to rain. Unfortunately, the research was not supported further. The ideas are very convincing showing that the energy investment in the process is dramatically small, only few cents for a cubic meter of added rain. From the laws proven and presented in the above chapter it becomes obvious that the addition of rain to above the average values contribute much more than the proportional rain addition to the ground water recharge. Addition of 20% rain would add 70% effective water addition to the ground water and similar proportion to runoff that may be used by flood interception in reservoirs. 30% additional rain would add more than 100% of the ground water recharge. The mixing energy has to overcome only a little more than the density gradient in the sea water profile due to the temperature gradient caused by the summer warm up.
Dr. Asaf's calculations showed that the whole volume to be mixed is in the order of one trillion cubic meter of water at a head difference of not more than some 0.1 meter. The total energy involved would be a fraction of kWh per additional cubic meter. Dividing the energy spent on such improved mixing of the sea by the effective addition of effective rain water gives a fraction of a kilowatt hour per cubic meter of distilled water. This means that the running pay per added cubic meter is one or two cents (assuming we shall have an energy source of the type we get from the Energy Tower). The initial investment may be large but much less than the investment involved in desalination equipment

for such a volume of about 1.5 billion cubic meter per year this would mean an initial investment of about 3 billion dollars a year using regular Reverse Osmosis. A mixing element and a work source with an output of some 300 million kWh per year spread on only 5 months and working 20 hours a day gives a power of 100,000 Kilowatts. The order of cost for such a system would be about 1000 dollars per kW. The overall investment then becomes of the order of 100 million dollars. Even if it is ten fold the investment it is still very small compared with a necessary investment in reverse osmosis that would be in the order of 3 billion dollars.
In one of the possible systems we can view a series of 100 boats dragging behind them a series of porous walls pipes that push out pressurized air and we get a water uplift with the air. One such unit will not cost more than a million dollars. Imagine a 100 meters wide path of this lift, and a speed of 10 kilometer an hour. The daily output would be 2 billion square meters sea area in a day. We have assumed 150 days totaling mixed area of 300 billions square meters. This is enough for mixing the full area three times in the summer.

- The whole concept brought by Dr. Gad Asaf calls our attention to the mechanism affecting the amount of rain. One must learn the warming up on one hand and the winter cooling on the other and on a regional basis.
- By the way, warmer sea water in the winter will reduce the demand for warming and cooler water in the summer will reduce the need for cooling.

Wave motion and sea streams, warm water piling due to wind shear and density differences of the sea water can also be utilized for mixing the sea water.
How would the rains or the droughts be correlated to the climatic changes. Can we get some feedback so that having a given technique for enhancing the rain volume will occur when it is needed.
The cooling process of the globe is certainly related to some extent to these processes. It seems that the studies concerned with the climatic changes have extremely low relevance with the major processes involved.
There is absolutely no question that the process of sea mixing and warming and the air humidity are essential for the future better understanding of the effects of climatic changes. It seems at least in some areas this could lead to the cheapest imaginable added water. The solar effects do the whole work. We shall only help their efficiency.
The potential contribution of Gad Asaf’s idea is so dramatic that the State of Israel cannot afford avoiding financing if even experimentally.

8. Methods for sea water desalination

8.1 Interrelation with renewable energy sources

8.1.1 The water value

One of the miss-concepts with respect to desalination of sea water is that the water is expensive. It has been shown that the economical value of supply reliability alone comes close to a whole dollar, significantly higher than the cost of desalination, itself today. Beyond that there are other values that have to do with values of nature, maintenance of the peripheral and rural inhabitation. This in turn may have tourist values, security issues etc. The actual value, of course, depends on the local standard of living and the characteristic activity which is related to the water use.

However, this justification for desalinated water may weaken out once the cost of desalinated water will become much more expensive due to the use of expensive fuel and due to the externalities caused by the use of fuel.

There are several possibilities to have a double use of the desalinated water. As an example the water may be used first in a revived river but then prevent it from running to the sea and peak it back up for any other use.

8.1.2 The best technology today

The best technology today is the "Reverse Osmosis". An installation of over 100 million cubic meters per year have already been constructed and operated. Typical figures are an initial investment of about two dollars per cubic meter per year. The rate of return is in the order of 20 cent per cubic meter. A typical power required is in the order of 4 kWh per cubic meter. Or typically it was at least 20-25 cents per cubic meter. On top of all these there is spending for desalination chemical treatment and post desalination treatment. Operation and maintenance further add to these. The cost per cubic meter in Ashkelon, Israel, was 56 ¢/m^3 (old cents).

8.1.3 Prohibitive price to come

Now that the fuel becomes more expensive and fines will be paid for producing greenhouse gasses. The cost of desalination is going to reach well over one dollar.

However, the amazing support of extremely inefficient methods to produce electricity desalination becomes completely out of the question. Imagine electricity at 2.01 Shekel per kWh or 48 (old) cents per kWh or 57 (present) cents per kWh - This brings the cost of one cubic meter sea water desalination to 2 dollars per cubic meter, and I mean old dollars. Today, in August 2008 it would be 2.4 dollars per cubic meters. This is a prohibitive price. This is especially so where the financial people will demand to relate to the marginal cost. Thus, we come to the conclusion that **there will be no solution to water supply problem without a real large scale solution to a cheap source of electricity from clean renewable source and without other unsolvable critical environmental problems. It is unfortunate that the vast majority of those declaring**

commitment to solve such problems are really narrow minded, short sighted and diverting from real solutions.

8.2 Desalination and Energy Towers

a. It has been shown that there is a possibility to desalinate very large water quantities in association with the "Energy Towers" in hot and dry zones (see chapter 6 above). Estimates showed a very high probability to reduce the cost to less than one half, i.e. less than 25 cents per cubic meter by old dollars (of early 2007). There is some limitation in this case because the desalination must be attached very closely to the chimney of the energy tower and this may not be convenient for supplying water to a far away district. Electricity transmission is relatively cheap. However, water transmission cost is in the order of 0.1 cent per cubic meter per one kilometer, not including overcoming large elevation differences.

b. A major advantage of the energy towers is that the price for electricity is initially lower, much lower than the cost of the electricity using fossil fuel.
c. The price of electricity is not going to increase relative to the general price index.
d. The desalinated water will be produced where it is needed most, the dry and hot areas that have no water now.
e. Some of the advantages that are obtained by the energy towers provide an advantage also to this component of desalination. One of them is the positive feedback to the climatic changes. When it is warmer and drier, the output of electricity is higher and more desalinated water could be obtained with the same installation.

8.3 A new revolutionary desalination method – "Mabua"

A novel physical principle has been used for desalination. There is no need for membranes. No need for evaporation and it can equally serve inorganic, as well as organic solutes. The main characteristics of the new principles are that we shall be able to avoid going down to the atomic scale in order to do the selection between certain solutes and the solvent. One possible hint to this advantage is the use of NF (Nano Filtration) that removes from the water higher valiancy solutes such as calcium magnesium and sulfates.

In three preliminary tests of the physical chemistry principles it has been found that the chances are practically proven to get the following:

a. The cost due to the initial investment and energy spending would be less than two tenths of the best alternatives.
b. It has been shown in actual measurements that over half the energy involved could be recovered.
c. The method is expected to be as effective with respect to organic solvents.

d. It seems that there are chances that there will be little or no sensitivity to the vital elements such as scaling, need to reactivate carbon absorbers.

It is not surprising that the attitude of some of those that have to approve the needed budgets to promote the revolutionary pioneering subject did for several years their best to kill it. Unfortunately this phenomenon is far too common.

8.4 Energy recovery from desalination

Every project of desalination has a by product of a concentrate or what is often called "end brine". The difference in vapor pressure between the original water source and the end brine point an opportunity to produce useful energy. There are several ways in principle to do that. A rough estimate indicates a possibility to recover and additional share, about one tenth of the energy spent on the desalination, to start with.

9. Ground water pollution

9.1 The basic problems

- There are three major water bodies that serve us, to conform the water supply curve to the demand when the natural supply is variable with too large amplitudes or too long cycles. Anything that we cannot make up will have to be supplied by desalination of saline water. This is the first mal effect.
- The second mal effect is the lower water quality that leads to the need to remove the pollutants at a high cost.
- The three water reserve bodies are ground water as aquifers, fresh water lakes and man made water reservoirs that holds flood and river water.
- Climatic changes and changes in the sea levels which in turn will have an effect on these storages in more than one way.

The sources of pollution are as follows:

1. Solutes brought in by the normal water supply. Their primary sources are sea water inflow due to over pumping. The aquifer water heads can come below the near by saline sea.
2. Many water sources lie as a fresh lens floating over some heavier saline water layer and sometimes even solid salt. Ground water around the water body can be at a head higher than the fresh water body and it comes in from the bottom into the fresh water body. It becomes more intensive as we pump out more intensively from the fresh water body. This is for example the case with the Lake of Galilee in Israel that feeds fresh water to large parts of the land and in the process supply annually 150,000 tons of salt.
3. Sewage water is made of fresh water with a considerable addition of solutes due to the human functions. It could easily add up to over 0.2 kg. solutes per cubic meter. It includes different salts, inorganic compounds the result of organic material disintegration, and finally organic solutes.
4. An important source of pollutants is waste piles accumulated around human settlements and agricultural production sites. This source is marked with a large variety of strange materials. Among them there are human hormones and different medicines leftover, different solvents and surface active materials, etc. The rate of nitrates flow from waste piled is of the same order as from sewage water.
5. Agricultural activity chemicals like fertilizers and plant protection materials.
6. Industrial leakages areas a very common source of pollution.
7. Another source of pollution is due to fuel leakages.

A basic rule is that prevention is mostly cheaper than correction. A second very important rule is that getting a certain amount of solute out of the water is more expensive as this

given quantity is diluted in a larger amount of water. As a general rule doubling the dilution will nearly double the cost.

Following in figure 14 one can see the concentration in parts per million of chlorides (the upper line) and of nitrates (the lower line). This is in the Israeli Coastal Aquifer and over 30 years, from 1970 to 2000. The two equations are:

$$[Cl]=2.42(t-1970)+122.1$$

$$[NO_3]=0.55)t-1970)+3.77$$

where - t - is the year.

Over 30 years the amount of chlorides has been increased by 80 milligrams per litter and the nitrates concentration by about 18 milligrams per liter. It is obvious that it is only a matter of time that the water will become unusable. Long before the whole volume will be useless, large parts will get out getting below the permissible standard. Obviously, irrigation with sewage water and sewage leakage to the ground is the worst part.

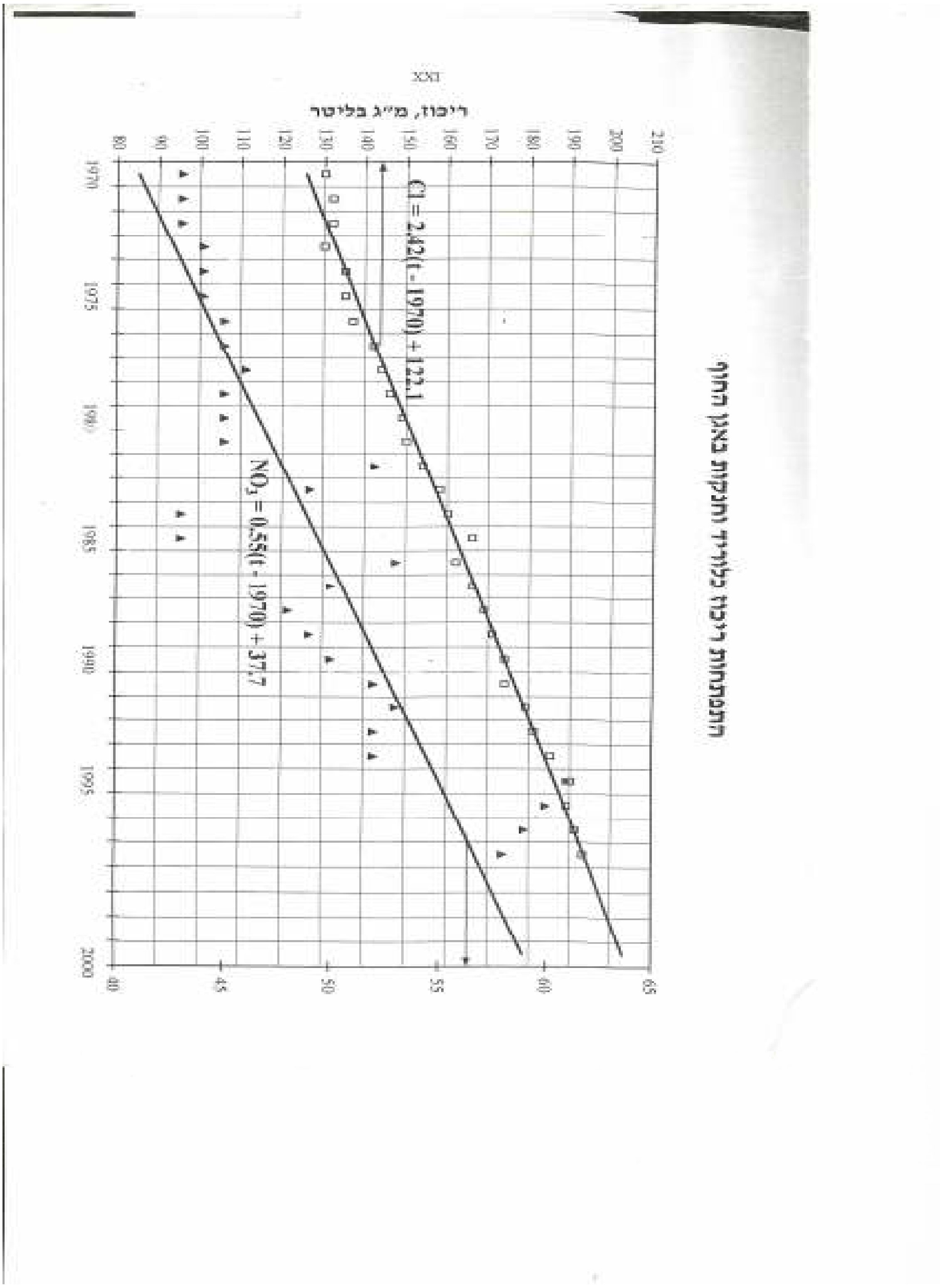

Figure 14 - The average change in chlorides and in nitrates in p.p.m. over 30 years as measured in the Israeli coastal aquifer. It shows the rate of aquifer pollution

9.2 Irrigation with sewage water - Is it a worth while thing to do?

Israel is proud about increasing the fruit of irrigation by a factor of 5-6. This involved in the water technology at least two major inventions. This is besides the improvement of plant variety, better care of the agricultural activity etc. The two major irrigation novelties were of drip irrigation (by eng. Simcha Blass) and the pulse irrigation, even daily watering in small water quantities and the grand total even less. It has been proven theoretically first and then experimentally to double the vegetative growth by daily irrigation compared to a weekly one. The fruit in a grapefruit plantation increase by 20% (Faculty of Agricultural Engineering - Technion, Israel Inst. of Technology, in Haifa).

These are still other necessary improvements like a better water distribution, reduced average head needed for irrigation and maintenance of even distribution despite topographic differences.

Are there other methods to increase the local capacity to utilize the water. I shall discuss briefly two of them as they are related to the major conceptual statements in this above write up.

a. One is the use of sewage water for irrigation.
b. The other is to utilize the phenomenon of lateral flow in the soil and lead small rain quantities to bear high fruit yield.

9.3 Reuse of sewage water

Many consider the best use of sewage water after a secondary treatment (precipitation, organic disintegration and possibly chlorination,) as reuse for irrigation. Very strict laws have been put against polluting the oceans by such a sewage. In our region it is known by "Barcelona Convention". Thus the only way to handle the sewage water is to leave it one way or another inland. In some more advanced countries they put some also strict limits on the quality of the sewage before it is allowed to be used in this way and thus they have suggested diluting it with desalinated sea water. Let us try to view this practice or a similar one.

As an undergraduate student of hydro-technology, over fifty years ago, I have been shown that irrigation is the best thing to do. Notably desalination was not a standard technology then with a reasonable economy. Let us reconsider the whole thing.

In Israel, within 30 years from 1970 to 2000, the chlorides content in the coastal aquifer the rate of chlorides content increased on the average from 125 milligrams per liter to 205 milligrams per liter. The increase in the content of nitrates over the same 30 years went up from 41 to 59 milligram per liter. As far as the nitrate content is concerned we came already very close to the upper permissible limit. Combining the two it shows that about half the volume of water concerned in this coastal aquifer now half of it is already unusable.

In addition to that all rivers running westward to the coasts of the Mediterranean Sea, are either dry because of water overusing or totally polluted by sewage water.

This situation in Israel can be used as a large scale experiment that dramatically points at several very strong rules:

1. Rule number one is that the volume of ground water that is below us will be fouled by human activities above it in a matter of several decades.
2. There must be found a way to get the pollutants out of there or we shall slowly destroy the operational volume that allows us to manage our water supply with the ability to conform the supply curve to the demand.
3. From the Israeli experience one could also learn that despite the sewage treatment it is still a source for different epidemics hurting badly the human society.
4. **The rule called the "Barcelona Agreement" disallow to throw the sewage, even after treatment to the sea. It must be mentioned to those that drew this law that the dilution of the sewage or its remnants in the Mediterranean Sea would be about 500 times larger than with the ground water under our feet. It is only a matter of time that the polluted water in the aquifer will be drained into the oceans any how so that the Bacelona convention is simply an idiotic superstition. It does not help the sea but it makes sure that we destroy our main water sources.. Then, why do we need this way to destroy the aquifers first and pay several times more for cleaning it? The best would be to desalinate the sewage water and bring it to perfect drinking water quality/ Using reverse osmosis the cost will not exceed some 30 cents.**
5. Those who were worried about the high solute concentration in the sewage suggested another idea which is probably the top of irrationality. The rule was set to dilute the sewage water with sea desalinated water with the ratio of nearly 4 to 1. By this dilution we do not prevent even a single gram of pollutant from reaching the Aquifer and eventually the sea. It increases the cost of the sewage water to the cost of 4 meters cubic desalinated sea water and then clear the salinity of the aquifer by desalinating 5 cubic meters- ingenious. As far as I remember, they used to call it in grade school "The Conservation of Matter". There are plans by the ministry of environmental protection to turn not lawful to believe in this law.

Still the sewage is a very reliable source of water if only we could avoid its damages. Following are the suggestions what to do:

1. **Desalinate the sewage and bring it to the quality of the best drinking water.**
2. **Get rid of the concentrates to the sea possibly after some further treatments disintegrating some components and even use some.**
3. **Use the high quality water for any purpose you want.**
4. **One of the uses is to revive rivers and peak back up the high quality water in the river before it is dispersed into the sea. Thus one has a double use of the same water.**

The questions remaining are: what is the cost of bringing the sewage water to drinking water quality. Is it at all practical?

1. The cost is approximately 20 cents per cubic meter (old dollars of early 2007).

2. We shall show in the following that the saving in doing that, is between a minimum of 1.5 dollar to 2.5 dollar per cubic meter of irrigation with sewage water. At present technologies of Reverse Osmosis the avoidance of using sewage water after secondary treatment could let us desalinate 3-5 cubic meters of desalinated sea water. Then, who needs the sewage water.

,The idea of dilution with desalinated sea water, cost even much more. This is due to the face that getting the solutes out of the water some far day would be multiplied almost exactly the same ratio as the solute dilution.

9.4 Why the irrigation with sewage water is so expensive compared with the desalination and bringing them to drinking water quality first

We can count over a dozen reasons for sewage irrigation being so expensive:

1. For the irrigation we have to store the water from winter to summer. Constructing and maintaining the reservoir with a reliable lining against leakage will cost around half a dollar per cubic meter (old dollar of early 2007).
2. The stay in the reservoir leads to some 20% evaporation of the water.
3. The fact that the nutritional chemicals remained in the water a new flora and fauna develop there. This leads to a need for filtration and chlorination of the sewage to prevent clogging the whole irrigation system.
4. The depth of irrigation water must be increase in order to leach out of the root zone the salinity brought by the sewage.

The extra cost is well above 0.7 dollar per original cubic meter. The cost per effective cubic meter irrigated is well above a whole dollar.

5. We shall have to get the solutes out of the ground water before long. Each cubic meter of sewage water may bring with it several hundred grams of solutes. The cost to get it out would be not less than half a dollar per cubic meter and even more for an effective cubic meter.
6. The relatively high proportion of sodium compounds lead to ion exchange in the clay fraction. It causes a process of dispersion that in turn clogs the soil, damages the aeration and produces a surface crust the damage the sprouting of seeds, soil aeration and irrigation.
7. Sodium, as a nutrient, damages the plants themselves.
8. The knowledge that sewage is used for irrigation will definitely damage the marketing weather justly or not.
9. Anywhere that sewage is being used for irrigation epidemics of different diseases is common. In recent reports by the Israeli Ministry of Health it shows that coli bacteria were found everywhere sewage was used for irrigation. A research woman in the Faculty of Food Engineering in Technion has reported about a disease in a military camp associated with the introduction of some vegetables irrigated by sewage water, even when this is done by all the

rules! One of the amazing observations is that some of the disease passing micro organisms are capable of passing from the soil water to the roots and from there through the plant stem al the way to the fruit.

10. The reservoirs storing the sewage water serve as a place for growing of mosquitoes.
11. It is especially convenient for spreading West Nile Fever.
12. The sewage water feed the ground water with bad pollutants such as human hormones leftover of different medicines, organic solvents etc. It must be demonstrated that while a typical ground water recharge by rain in Israel is about 1.5 billion cubic meter a year the sewage recharge, at least the pre-evaporated quantity is about half a billion cubic meters. It means that the amount of sewage compounds in a glass of water approach one quarter!
13. There is a series of Jewish religious laws that prohibit intake of such foul things.

It may now become clear why the proven real damage approaches 1.5 to 2.5 old dollars (of early 2007) per cubic meter of sewage applied to the ground for watering. It means that in avoiding this damage alone we could have justified 3to 5 cubic meters desalinated sea water.
Adding to it the fact that the volume of the sea is thousands time larger than all the ground water. Moreover, the future use of sea water through natural production of rain or through any desalination method will not suffer from any mall effect by the solutes which have been disposed to the sea. Still, direct desalination of the sewage water and disposal of the concentrates to the sea is the cheapest. The active ground water body that drew the Barcelona rule that disallows disposing of sewage water to the sea or any country that have signed it should get a certificate of bad mismanagement.

10. A couple of examples for the right type of projects

10.1 A land cleaning system

1. A law should be passed not to allow the termination of pumping from a well that was found to be polluted. The pumping must be continued and the polluted water cleaned.The concentrates will e sent to the sea.
2. The water authorities should build a system of pipes to collect the concentrates from polluted wells and sewage treatment. In fact, it is possible to design movable desalination units that could be attached from time to time to wells which turn out to be polluted.
3. The above does not relieve the state from trying to prevent pollution by all seven contributors (see above.)
4. The cleaning pumping from the aquifers can very easily adapt to climatic changes by adjusting annually the rate of pumping with respect to the position of the sea surface.
5. This whole approach cannot be obtained without the concentration of know-how and authority in one public authority. There must be a central performance, too. This does not relieve polluters from paying.
6. The electricity will be obtained from energy tower which are described above. It may be fed from the regular system by improving the efficiency of energy use, by wind energy and by utilizing waste and producing bio-gas.
7. The local desalinization could lead to revival of polluted or dry rivers and the water recycled later to any other use.
8. The above system provides us with the best tool to overcome situations of water shortage by over pumping. This is because the aquifers would be clean and the damages caused by over pumping can be easily corrected. It prevent the need for major projects decades ahead of time and does reduce dramatically the average running cost to about half.

Note that the pumping system will remain relevant for all times and all climates. They may be used without desalination as long as possible and arrange for cleaning when it become necessary. The desalination may be stopped again without major funding losses but rather in small shares. New methods of desalination could be adapted as they are ready.
Why is it that such a straight forward possibility does not happen and not even in discussion and in giving weights to research and development subject such as desalination methods. Nano-Filtration, addition of sea water to desalinated water in order to supply of essentially needed elements and response to water level changes.

10.2 The Northern Alternative for handling a combination of problems all over the country

We may combine the following:

1. The mass of electricity will be produced by the Energy Towers at any needed level.
2. The pumping from the lake of Galilee will be gradually stopped and its water to the main water conduit will be replaced by seawater desalination along the Mediterranean Sea shore. Anticipated gain is about one Dollar per cubic meter due to high reliably. Another gain will be in the order of about half a dollar per cubic meter due to the prevention of salinization of nearly half a kilogram per cubic meter brought in by every cubic meter of Lake of Galilee water. The cost of desalination is assumed to be half a dollar per cubic meter. Thus, we have already a net benefit of about a whole dollar per cubic meter.
3. The water released down the Jordan will save this River of unusual global history which is now nearly dry and polluted. We do not have any formal value but it must be far more important than the so called "saving the Dead Sea".
4. The water that will come down the Jordan will add water to the Dead Sea delaying the marginal descent of the sea water surface by few hundreds years.
5. The fresh water will be used to dissolve the precipitated slat in pond number 5 which serves as the main source of raw material for the Dead Sea Works.
6. The above will also eliminate the danger of pond number 5 burst that will destroy the near by hotels. In view of the funds that some are ready to pay for the so called "Dead Sea Saving" , the net annual profit is near one billion dollars!!! Not cost, but rather huge profit.

How come such an alternative that has been suggested raised objections expressing complete ignorance, all kinds of selfish interests, etc.

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