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I am Bryce Johnson, a retired nuclear engineer with 47 years experience in the field. That makes me prejudiced toward nuclear energy, but prejudice does not equate to being wrong any more than a lack thereof equates to being right.

When choosing sources of energy, the attributes of longevity (amount of the source), cost, energy efficiency and safety are paramount. It is difficult to determine the order of importance of these attributes because they are all interrelated. A subset of safety, the lack of harmful emissions, is specifically treated because of the current national obsession with greenhouse gases and global warming.

Only solar and wind energy of the renewable sources will be discussed because these are the cornerstone of the CEC's energy plan and because these have the greatest potential for expansion.

In terms of longevity, solar and wind are forever, so they easily claim the prize in that attribute. U. S. coal is estimated to last 250 years; oil is but a few decades away, at best, from becoming prohibitively expensive, even though not entirely extinct. Natural gas, have been recently augmented by development of horizontal drilling and fracturing in shale deposits to bring this source back from the brink of extinction. This is fortunate in part because natural gas can replace oil as a fuel for internal combustion engines which are essential for maintaining of our current civilization. But this silver lining has a cloud. These wells have significantly less gas than the traditional gas wells and have increased the number of wells required per unit of gas production. These facts do not bode well for sustained natural gas supplies, but they may still provide a bridge from the inevitable oil shortfall to a more sustainable means of maintaining our live-preserving internal combustion engines.

In contrast to oil and gas, nuclear energy sources are so huge that they can be treated as renewable. Both uranium and thorium, which are abundant elements in the earth's crust, can produce a staggering amount of energy per unit weight, typically two to three million times as much as that of fossil fuels. In the current nuclear power reactors, only 0.5 percent of the mined uranium readily undergoes fission. That still amounts a 15,000-to-1 energy production advantage over fossil fuels. Advanced reactors have been developed, primarily in the United States, that convert the initially non-fissile portion of the uranium (U-238) to that which can fission and thereby, increase the energy production by at least 100-fold, and the United States has sufficient U-238 that is already mined and separated to supply its entire needs for over 700 years in these advanced reactors! Unfortunately it is our government's policy not to deploy these reactors, while France, Russia and Japan utilize the technology developed in the United States to vastly multiply their energy resources.

"Energy efficiency" as measured by energy payback ratio (EPR) the ratio of energy output to the energy input required to produce the output. Energy returned on energy

invested (EROEI) is another common term for it and it can vary from nearly zero to very large numbers. It significantly impacts the cost and longevity of the source. While EPR is simple in concept, its determination is difficult because of the great many factors contributing to energy input and the difficulty in determining appropriate values for these. These problems produce a wide range in individual EPR estimates and provide ample opportunity for biasing the results. Typical EPR values for energy sources are shown below.

Nominal Energy Payback Ratios for Various Energy Sources

Energy Source	Average EPR
Advanced nuclear fuel cycles	> 1000
Hydroelectricity	99
Current once-through nuclear cycle, centrifuge enrichment	51
Coal	19
Current once-through nuclear cycle, diffusion enrichment	19
Wind (accounting for intermittency)	18
Natural Gas	12
Oil (Saudi Arabia)	10
Liquid Natural Gas	6
Solar thermal (accounting for intermittency)	6
Solar electric (accounting for intermittency)	5
Oil (U. S)	3
Ethanol, Biodiesel	< 1 - 2.5
Canadian Tar Sands	< 1 - 2.5

Similarly, Cost numbers are listed below. These numbers are from the Europe U. S. numbers would have been preferred but, but U. S energy organizations seem determined not to commit to a side-by-side comparison. The numbers represent an average between 2005 and a projection to 2030.

Gas - 4.325 (in hundredths of a euro per kwh)
Coal - 5.3
Nuclear - 4.75
Wind - 7.8

There is no reason to expect the United States or California to differ significantly from these figures. Gas, coal and nuclear are all within a few percent of each other, but wind is almost double any of these. California's latest published solar electricity cost was 22 c/kwh. But it is claimed that that can be reduced to 13. Conceding that the state can produce half of the claimed reduction, shows that solar is more than twice the cost of wind and more than three times the cost of nuclear or fossil fuel. California is basing its electric future on the world's two most costly sources. And the state is paying exorbitant subsidies for these sources when it is up to its eyeballs in debt

Below are the grams of carbon released per kwh for each power source as an average of plants in Japan, Sweden and Finland

Coal	- 950
Gas (thermal)	- 882
Gas (cc)	- 480
Solar Voltaic	- 66
Wind	-16.2
Nuclear	-15.3
Hydro	-7

Gas is not significantly different than coal in carbon emissions, and even by the CEC's projection we'll be using mostly gas for decades to come. Nuclear matches or exceeds all other in terms of sustainability, energy efficiency and cost; and hydro and nuclear are the best relative to carbon emission. But the state government maintains a law against nuclear power and hydro sites are used up. So we are stuck with wind, solar and natural gas for our energy future. The only thing wrong with this limitation is that it is inadequate for our future energy needs. The sustainability of natural gas is by no means assured and the conventional wisdom among energy experts, including the president of the American Wind Energy Association (AWEA) is that the renewables of wind and solar can never exceed 20 percent of our energy needs. Beyond that level the intermittency would impose impossible restrictions The CEC calls for us to achieve 30% in ten years. The same president of AWEA has said that it would require 30 years to achieve even 10 percent. The CEC plan is totally devoid of any realism.

The state currently bans nuclear energy because a waste repository must be licensed and reprocessing of used nuclear fuel has yet to be achieved. Since the national government has cancelled both of these projects, permanence of this ban seems assured. But without reprocessing, we will never achieve the closing of the fuel cycle and we will never expand our nuclear energy capacity by the factor of 100 that this enables.

Further the irrational fear of nuclear waste that has been allowed to invade the national psyche is probably the greatest hoax that has ever been perpetrated on a large group of people. Nuclear waste is never has been a real safety issue and it and never will be. Used nuclear fuel has been safely handled for over 50 years in this country with no incident and no one being harmed because of the effective procedures that are in place. Due to its radioactive decay, the used fuel can be safely handled within 15 to 20 years of removal from the reactor. There is no necessity for millions, tens of thousand or even many hundred of years of storage and it doesn't have to be stored underground. We routinely deal with hazards that are hundreds of times more likely to harm us than nuclear waste and we completely ignore them

But I have digressed from the CEC energy plan. I did that because nuclear power is the only means of solving California's energy problem. And I wanted to explain the folly of holding it hostage to the reprocessing and nuclear waste issues.

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I would summarize the current CEC energy plan as a means to guarantee that California will be the first political entity to suffer the cataclysm of an energy shortfall and also to assure that we pay the world's highest price for the energy we manage to produce on our way to economic oblivion.