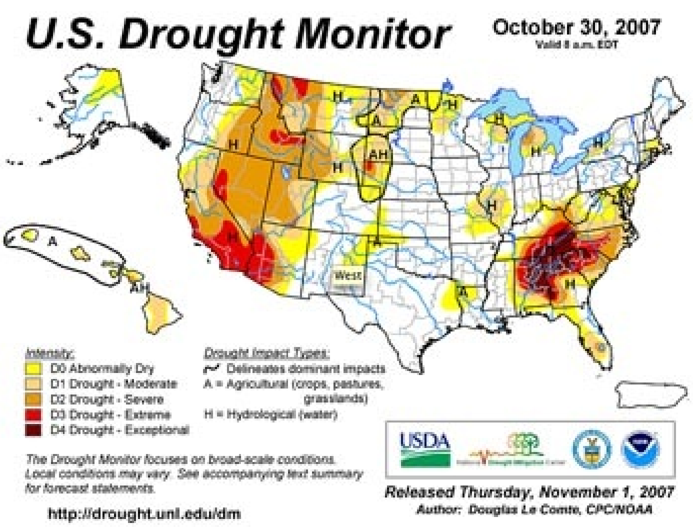
The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The needs and use of water for power, industrial plants and people

Posted by Heading Out on November 6, 2007 - 10:10am
Topic: Demand/Consumption
Tags: cap, consumption, evaporators, original, process water, sagd, south africa, southern california, water [list all tags]

I was recently in a meeting with some State officials, and representatives of a large fossil energy supply company. The meeting was largely focused on State-centered efforts to increase the amount of renewable or sustainable energy. In the course of the discussion the company representatives raised the issue of water availability, and how this might impact some of the options. It is a subject that is starting to raise its head in more than just this type of discussion. If we look at the current drought status of the United States, for example.



The exceptional drought in the South East and the extreme drought in the South West are both evident. The growing impact of the sustained lack of water, or the need to provide water to an increasing number of people or a growing industrial base, from a fixed resource, is one that will have an impact that goes beyond just the immediate short term. And so, being curious, I looked at the major users of water, and what they did with it. And it was in this light that I then looked at one of the promising new technologies that Dave Rutledge had mentioned at the ASPO conference, the use of concentrated sun power (csp), and in the process I also looked at how they are handling process water in the oil sands of Alberta.

So where does the majority of the U.S. water go? Best folk to ask seem to be those folk over at the

US Geological Survey. And to quote one of their reports:

> Estimates of water use in the United States indicate that about 408 billion gallons per day (one thousand million gallons per day, abbreviated to BGD) were withdrawn for all uses during 2000. This total has varied less than 3 percent since 1985 as withdrawals have stabilized for the two largest uses—thermoelectric power and irrigation. Fresh ground-water withdrawals (83.3 BGD) during 2000 were 14 percent more than during 1985. Fresh surface-water withdrawals for 2000 were 262 BGD, varying less than 2 percent since 1985.
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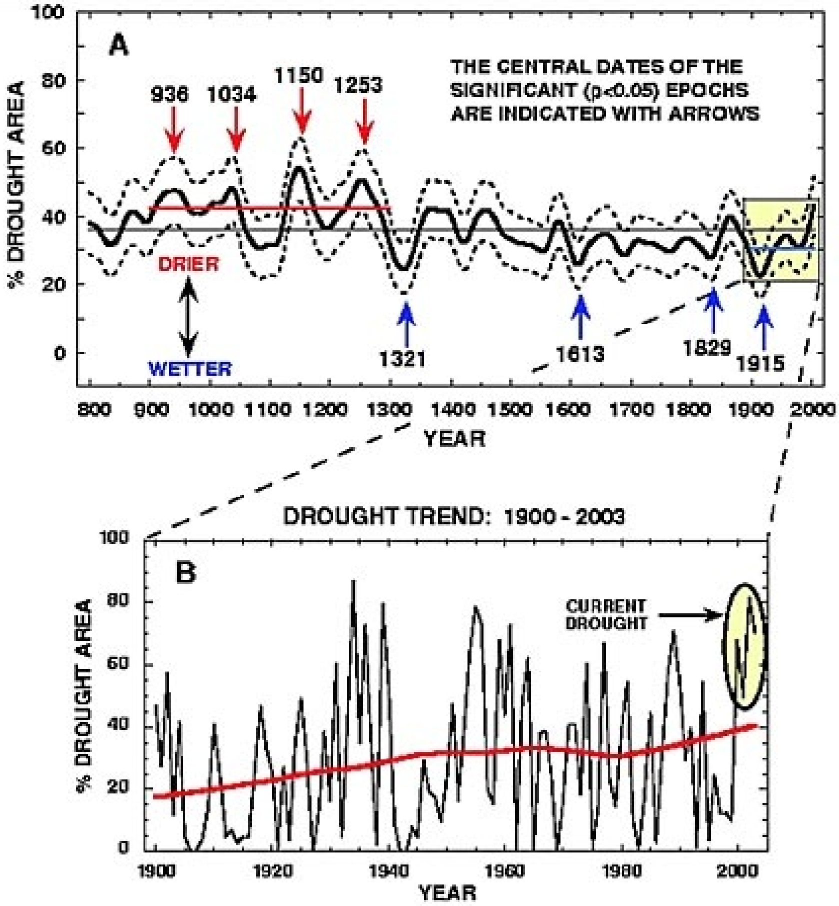
> About 195 BGD, or 48 percent of all freshwater and saline-water withdrawals for 2000, were used for thermoelectric power. Most of this water was derived from surface water and used for once-through cooling at power plants. About 52 percent of fresh surface-water withdrawals and about 96 percent of saline-water withdrawals were for thermoelectric-power use. Withdrawals for thermoelectric power have been relatively stable since 1985.
>
> Irrigation remained the largest use of freshwater in the United States and totaled 137 BGD for 2000.

That is a fair volume of water, particularly for the amounts that are single-use pass through. Now a lot of this water is returned to the source, but still a significant amount is lost to evaporation. And thus there is currently a program within the National Energy Technology Lab (pdf), to look into this. But before I get there I think it is useful to put the current conditions in context.

I am one of those folk that think that we can learn from the past, and so I went to see what the history of droughts were in the South-West. I found that we appear to be heading back into the same sort of cycle that hit about 1100 years ago. And one of the things of concern, if one looks at the following graph, is the length of time that the droughts lasted. I have noted, earlier, that droughts in New York at this time lasted around 200 years. The evidence from Southern California, reported by Seager, Herwijer and Cook seems to show the same sort of duration.



And again, as one of the intriguing little quotes that illustrate the point let me add a quote from the paper

> In a remarkable paper ('Late Quaternary bison population changes on the southern Plains', Plains Anthropologist, v 19, 180-196, 1974), Tom Dillehay successfully sketched the medieval climatological history of the southern Great Plains based on little more than the numbers of bison bones found in archaeological sites. At this time few Indians were dependent on bison hunting - that was yet to come when European expanded into the moister areas to the east and displaced Indians from areas where they both farmed and hunted. In Dillehay's study it is striking how few were the bison remains a millennium ago compared to the periods before and after. He also drew what now appears the correct conclusion - the climate was drier and bison populations shrank as grasslands became desert.

One can follow this further, the drought conditions in the South-west at the time led on to significant health issues (pdf) (not to be topical!).

> In coastal California, the effects of a punishing late Holocene environment are found in recent archaeological discussions. Arnold (1992) and Raab and Larson (1997) identify patterns of site abandonment, increased rates of disease, malnutrition, and interpersonal violence along the Santa Barbara coat during the MCA (Lambert 1994, Lambert and Walker 1991). Stress-related phenomena, such as elevated levels of disease and incidents of warfare, stemmed from the competition among prehistoric peoples for the resources which were severely diminished by the climatic changes discerned (Fischman 1996). Similarly Jones et al. (1999) document settlement pattern

> hiatuses, shifting dietary regimes, sharply increased levels of violence, disruption of regional trade networks and other cultural patterns that correlate with the MCA in California, the Great Basin, and in the American Southwest.

These drought conditions extended much further south, and one also reads of this being a reason for the Collapse of Mayan Civilization .

> During its Classic period (250–950 A.D.), Maya civilization reached a zenith. At its peak, around 750 A.D., the population may have topped 13 million. Then, between about 750 and 950 A.D., their society imploded. . . . . . In his fascinating book, The Great Maya Droughts, independent archaeologist Richardson B. Gill persuasively argues that a lack of water was a major factor in the terminal Classic collapse. Gill pulls together an enormous amount of information on modern weather and climate, draws on the record of historical droughts and famines, and heaps on evidence from archaeology and from geological studies of ancient climates. . . . . . . Gill builds an impressive case. When his work was first published (five years ago), the most compelling evidence for drought came from sediment cores that David A. Hodell, Jason H. Curtis, Mark Brenner and other geologists at the University of Florida had collected from a number of Yucatán lakes. Their measurements of these ancient deposits indicate that the driest interval of the last 7,000 years fell between 800 and 1000 A.D.—coincident with the collapse of Classic Maya civilization.

Looking at the current wet and dry pattern over the United States, one is then led to wonder what happened in this time interval in the central part of the country. This is the part that is currently not in the drought zone. And it turns out that it wasn't then either. This was the time of the rise of the Indian Civilization at Cahokia Mounds in Illinois.

> The archaeological remnants at Cahokia Mounds, near Collinsville, Illinois, have been preserved to tell the story of the most sophisticated prehistoric Indian civilization north of Mexico. According to the finds, the ancient city of Cahokia, from about A.D. 700 to 1400, covered nearly six square miles. Originally, there were over 120 mounds. . . . . It is believed that the population of the city peaked at 20,000 from 1100 A.D. to 1200. The fate of the culture is unknown, although historians attribute a climate change that may have affected crop production, plant and animal resources and possible war, disease and social unrest.

This could perhaps have been the start of the Little Ice Age.

Hmmm! So if we are going back to the weather of about 1100 years ago, how do we stop everyone leaving the drought stricken coasts and moving to Illinois – which might start to get a tad overcrowded after a while.

Well this is where I go back to what we are doing with the water from the power stations. The majority of the water used in power stations is either turned into steam to drive turbines, or used in cooling – this is one of its functions also in some of the biofuel refineries. A 500 MW power plant that uses once-through cooling, uses over 12 million gallons per hour for cooling and other requirements. Currently most of this water is recycled and returned to the environment from which it came, so that the absolute use in power stations, for example, is only 3 percent when this is taken into account. But it is another figure in that report that is also relevant. Power stations take up 60 BGD of saline water, to reduce the demand on freshwater that they would otherwise impose.

So there are two points that can be made from this, the first is that power stations can be engineered to use water that is not currently viable as potable water for use domestically and by industry, and the second is that, in the processing of the water for their own use, industry is already cleaning up the water, so that the resulting condensed steam and clean product can then be fed back to society to remediate some of the coming problems with water shortage. Consider, if you will, that this is converting power plants into concurrently becoming desalination plants.

Remember that each kWhr of electricity currently requires 25 gal of water .

I have used the word desalination, since there are many power stations near the coast that could provide this additional water source (and perhaps some already do) But water cleanup is an ongoing process in many mining operations. There is, for example, a program in South Africa that is desalinating mine water for use in power atations. If one looks at the video shown in the description of the concentrating solar power the very hot oil from the concentrators is fed through water to generate steam, which drives turbines. There is nothing but some clever engineering that precludes this from using contaminated or saline water as the feed,, and condensing the steam to provide a rsource for those who are starting to become starved of it.

One of areas of the world where water supply is already causing concern, in its ability to restrict future expansion is in the oil sands of Alberta. Here, even though the processes are increasingly efficient in their recovery of water, the projected growth will still place an increasing burden on the supply of make-up water to the various processes. This becomes increasingly so where Steam-Assisted Gravity Drainage is used to recover the heavy oil from underground deposits. In a traditional Once-Through Steam Generator (OTSG) some 20% of the water will form a concentrated brine that carries the water treatment and pollutant chemicals, and this has to be either disposed of or further processed through a Zero-Liquid-Discharge facility that produces a dry product for disposal. In the more modern technology, which uses vertical-tube evaporators the process water that is recovered after the steam has been injected, is recycled through the plant for re-use. The simpler evaporation system is now becoming increasingly adopted, and is largely considered to also be more economic. Of additional interest it also lowers the fuel cost requirement for the process by about 1-5%. Energy demand for the operation of the evaporator runs at around 60 – 70 kWh/ 1,000 gallons distillate (the higher end includes crystallization of the solid waste stream).

The ability of industry to utilize undrinkable water, and to convert this, while utilizing it in pass-through mode, to water that can be provided as a resource to the community is something that we may need much more of in the future. It is perhaps reassuring to find that there is a technology out there that will allow this to happen.