DOCKETED

Docket Number:	18-MISC-03
Project Title:	Renewable Energy for Agriculture Program
TN #:	225069
Document Title:	James Workman Comments Unlocking energy gains from a targeted approach to agricultural groundwater pumping
Description:	N/A
Filer:	System
Organization:	James Workman
Submitter Role:	Public
Submission Date:	10/22/2018 9:47:37 PM
Docketed Date:	10/23/2018

Comment Received From: James Workman
Submitted On: 10/22/2018
Docket Number: 18-MISC-03

Unlocking energy gains from a targeted approach to agricultural groundwater pumping

We believe there are far more energy gains that would come from focusing on groundwater and the energy required to pump more water from greater depths.

1. Market Incentives. SGMA requires local groundwater sustainability agencies (GSAs) to reduce groundwater use to sustainable levels, but success is by no means assured. To the contrary, GSAs that simply impose curtailment requirements on well owners â€“ forcibly rationing stakeholders from 10-70% -- will invite controversy, to put it mildly. Well owners are talking about open revolt: political protests, regulatory pushback, civil litigation, delayed action. Concurrently, the influential membership of the California Farm Bureau Federation and of the Agricultural Energy Consumers Association have petitioned for relief as energy rates escalate due to lost surface water as irrigators must pump more from aquifers sinking to lower depths. Given the political landscape, the state Water Board has offered a frank assessment: for SGMA to succeed, over-drafted basins need real incentives from cap-and-trade markets to achieve sustainability.

2. New Economic Value from Curtailment. Pumping activity is a moving target. While no entity tracks every well, the Californiaâ€™s Department of Water Resources (DWR) has reported that state-wide groundwater extraction for the decade ending 2015 averaged of 16,000,000 acre-feet (AF), with 3,000,000 AF (18%) over-drafted or depleted. That rose in recent years of â€œbelow averageâ€□ rain and snowfall, when groundwater use exceeded 20,000,000 AF, with an overdraft of 6,500,000 AF. In economic terms, all that water was â€œfree.â€□ It had no value in exchange. The only internalized cost to well owners was the rising expense of energy to pump it (see #1 above), and the externalized cost was the emissions caused by pumping. Although California now prices carbon with market trading, the potential upside from reduced pumping has not yet to our knowledge been quantified for well owners. AquaShares estimates the opportunity to â€˜zero outâ€™ overdraft levels would equate to reduced electricity utility-generated emissions of 500,000 tons CO2/year. At recent prices in the stateâ€™s carbon market, this would in aggregate have an economic value of $7.2 million/year, or $360 million over SGMAâ€™s 50-year planning horizon.

3. Carbon Gains from Higher Water Tables. Additional value may come in the form of restored groundwater supply levels. The sooner well owners manage to stabilize and/or raise aquifer levels, the more energy they save by lifting the same amount of water shorter distances. By investing in water efficiency now, they could lock in compound carbon gains for years to come. While GSAs have not yet submitted initial sustainability plans (GSPs), SGMA requires protection/restoration both of functioning groundwater dependent ecosystems (GDEs) and of residential wells on which disadvantaged communities depend. Raising water depth levels by 25% [for example, from 200 feet to 150 feet deep] would drive an equivalent reduction in utility-generated electricity, and thus slash carbon emissions by an additional 125,000 tons CO2e/year.

That could generate added value of $1.8 million, or $90 million over SGMAâ€™s 50-year horizon.

4. Embedded emissions. The bulk of greenhouse gas due to groundwater extraction is indirectly linked to the generation of electricity to run powerful pumps. Yet a quantifiable and significant amount of pollution is also caused, directly, by the physical act of depletion itself. Recently, scientists have discovered that due to subterranean chemistry, Americaâ€™s groundwater depletion releases, by one estimate, 1.7 million tons of CO2e into the atmosphere every year. Using this same calculation methodology applied to the volume of over-drafted groundwater in California, cap-and-trade markets could eliminate an average of 250,000 tons of CO2e, and more than double that amount in dry years, with equivalent economic values of $3.6 - $7.2m annually, or an expected $180 million over 50 years. By developing a standard methodology for calculating this type of emissions, incentives could then be created for reducing them.

5. Time of Use Shifting. Volume and elevation are two factors in of emissions reduction. Timing is another. Incentives could potentially induce well owners to choose not only to pump less from elevated water tables, but choose when during the day to pump it. How much CO2e emissions this could reduce remains TBD, but this proposal is interested in investigating how shifting use patterns of groundwater pumping from peak hours to off-peak hours may reduce stress on the stateâ€™s electric grid and fossil fuel burning, offering yet another source of economic value.

Additional submitted attachment is included below.

Incentives for smart pumping by well owners could reduce California emissions 1 MMT annually

DRAFT concept linking and exploring groundwater/energy/carbon nexus

Background

Against federal climate change denial and inaction from above, North America's vulnerable cities, counties, and regions are pursuing new ways to reduce greenhouse gas emissions from below. California – ranked first in the U.S. in population, economic activity, and agricultural value – is seeking to galvanize this bottom-up effort, and has been leading by example. The Air Resources Board has prepared a comprehensive CO2e inventory and through enactment of AB32 in 2006 has established a proven cap-and-trade market mechanism to reduce industrial greenhouse gases (GHGs).

Beyond industrial carbon, CA's scoping plan finds agriculture causes eight percent of all emissions. Livestock fermentation and manure, rice cultivation, fuel combustion, crop residue burning, and soil amendment by fertilizer and manure all generate GHGs. That plan also highlights existing, well-worn plans that could turn 'smart farms' from pollution sources to emissions "sinks" that sequester soil carbon.

Yet the silo effect of regulated sectors – air, land, water – may hide an opportunity that links all three. This proposal seeks to explore, and transform, what has thus far been a largely unrecognized and thus unaccounted for source of emissions, generated by both rural farms and urban families: groundwater.

All too often, groundwater is seen only through a lens of climate adaptation. In the Western U.S. in general, and for California in particular, droughts have in recent decades increased in frequency, duration and magnitude. As a resulting coping strategy, aquifers have in arid years replaced rivers as the primary reliable source of water by which Californians quench their thirst. Nationwide, more than half of all Americans – and 85 percent of Californians – depend on groundwater; it supplies much or most of all farm water, including CA's $45b irrigated agriculture industry. Under the status quo, without incentives, scientists project that diminished snowpack and runoff, combined with higher evaporative losses, will only further intensify California's urban and especially rural dependence on groundwater resources.

Dependence introduces a complicated problem -- and also potential solution. For beyond its climate adaptation role, groundwater pumping directly and indirectly generates a meaningful source of emissions, exposing California, and the entire U.S., to seven significant and unreasonable risks – unless mitigated.

The first six most immediate risks are local. Decades of unchecked over-drafting have brought "six undesirable results" across the State:

declining water tables; lost storage; seawater intrusion; degraded quality; land subsidence; and surface water depletion. It's a national problem. The U.S. has over-exploited groundwater by 1,000 cubic kilometres – at an escalating rate of more than 25 km3 (~21 million acre feet) per year, yet California depletion stands out, by itself contributing 1/7th to 1/3rd of America's overdraft.

Although it was the last Western state to regulate pumping, California is now racing to compensate. The landmark 2014 Sustainable Groundwater Management Act (SGMA) mandates and devolves authority to hundreds of basins, which have formed distinct groundwater sustainability agencies (GSAs), each drafting its own robust plan to balance supply and demand. Local governance is fitting when it comes to rigorous oversight, hydrology, monitoring, compliance and decisions about reduced withdrawals, increased recharge, or tradable credits. Yet groundwater pumping is both cause and consequence of global warming. That means we can simultaneously adapt to change *while* mitigating CO_2 emissions.

Opportunity to Study the Groundwater, Energy, Emissions Nexus

Indeed, given SGMA's regulatory context, and the extensive use of electrical pumps to extract heavy water from ever increasing depths, AquaShares sees an opportunity to study, document and analyze the extent to which a cap-and-trade market structure could avoid and reduce excessive energy demand and associated carbon emissions through more judicious groundwater pumping, creating net gains in value for the basin, state, country, and indeed planet.

How can a local resource have global implications? In a word: mass.

Groundwater is surprisingly, almost unfathomably heavy. A one-pound pint at a bar becomes an eight-pound gallon jug at the grocer. Scaling up: just 264 of those gallons make up a ton, there are two thousand tons in a single acre-foot (AF); in drought years California hoists 20 million (AF) – 6.5 million AF more than rain or snow can refill.

Forty billion tons overcome gravity only by applying vast amounts of energy. It is hard to lift a water load twelve vertical inches from a rest position; it takes twice as much energy to raise it two feet. Today one million active wells are engaged in a race to the bottom – a bottom fast receding past its current average depth of *two hundred* feet below. For every inch water tables plunge, grid demands proportionately rise.

The scope of our proposal – to explore the groundwater-energy-carbon nexus – seeks to examine several influential components, linked forces that may increase or decrease resource demand. These are: market incentives, curtailment targets, distance to surface, embedded gasses, and timing of pumping.

1. ***Market Incentives.*** SGMA requires local groundwater sustainability agencies (GSAs) to reduce groundwater use to sustainable levels, but success is by no means assured. To the contrary, GSAs that simply

impose curtailment requirements on well owners – forcibly rationing stakeholders from 10-70% -- will invite controversy, to put it mildly. Well owners are talking about open revolt: political protests, regulatory pushback, civil litigation, delayed action. Concurrently, the influential membership of the California Farm Bureau Federation and of the Agricultural Energy Consumers Association have petitioned for relief as energy rates escalate due to lost surface water as irrigators must pump more from aquifers sinking to lower depths. Given the political landscape, the state Water Board has offered a frank assessment: for SGMA to succeed, over-drafted basins need real incentives from cap-and-trade markets to achieve sustainability.

2. ***New Economic Value from Curtailment.*** Pumping activity is a moving target. While no entity tracks every well, the California's Department of Water Resources (DWR) has reported that state-wide groundwater extraction for the decade ending 2015 averaged of 16,000,000 acre-feet (AF), with 3,000,000 AF (18%) over-drafted or depleted. That rose in recent years of "below average" rain and snowfall, when groundwater use exceeded 20,000,000 AF, with an overdraft of 6,500,000 AF. In economic terms, all that water was "free." It had no value in exchange. The only internalized cost to well owners was the rising expense of energy to pump it (see #1 above), and the externalized cost was the emissions caused by pumping. Although California now prices carbon with market trading, the potential upside from reduced pumping has not yet to our knowledge been quantified for well owners. AquaShares estimates the opportunity to 'zero out' overdraft levels would equate to reduced electricity utility-generated emissions of 500,000 tons $CO2$/year. At recent prices in the state's carbon market, this would in aggregate have an economic value of $7.2 million/year, or $360 million over SGMA's 50-year planning horizon.

3. ***Carbon Gains from Higher Water Tables.*** Additional value may come in the form of restored groundwater supply levels. The sooner well owners manage to stabilize and/or raise aquifer levels, the more energy they save by lifting the same amount of water shorter distances. By investing in water efficiency now, they could lock in compound carbon gains for years to come. While GSAs have not yet submitted initial sustainability plans (GSPs), SGMA requires protection/restoration both of functioning groundwater dependent ecosystems (GDEs) and of residential wells on which disadvantaged communities depend. Raising water depth levels by 25% [for example, from 200 feet to 150 feet deep] would drive an equivalent reduction in utility-generated electricity, and thus slash carbon emissions by an additional 125,000 tons $CO2e$/year. That could generate added value of $1.8 million, or $90 million over SGMA's 50-year horizon.

4. ***Embedded emissions.*** **The bulk of greenhouse gas due to groundwater extraction is indirectly linked to the generation of electricity to run powerful pumps. Yet a quantifiable and significant amount of pollution is also caused, directly, by the physical act of depletion**

itself. Recently, scientists have discovered that due to subterranean chemistry, America's groundwater depletion releases, by one estimate, 1.7 million tons of CO2e into the atmosphere every year. Using this same calculation methodology applied to the volume of over-drafted groundwater in California, cap-and-trade markets could eliminate an average of 250,000 tons of CO2e, and more than double that amount in dry years, with equivalent economic values of $3.6 - $7.2m annually, or an expected $180 million over 50 years. By developing a standard methodology for calculating this type of emissions, incentives could then be created for reducing them.

5. ***Time of Use Shifting.*** Volume and elevation are two factors in of emissions reduction. Timing is another. Incentives could potentially induce well owners to choose not only to pump less from elevated water tables, but choose when during the day to pump it. How much CO2e emissions this could reduce remains TBD, but this proposal is interested in investigating how shifting use patterns of groundwater pumping from peak hours to off-peak hours may reduce stress on the state's electric grid and fossil fuel burning, offering yet another source of economic value.

Questions to Address

Taken together, these elements suggest it could be possible to realize significant [>1MMT CO2e] value across the state – and by extension and example the U.S. and world -- by exploring the groundwater-energy-carbon nexus. We would seek to quantify how cap-and-trade markets could create an incentive structure for groundwater well owners to curtail use, pump judiciously, stabilize and/or raise water tables, and drive down corresponding carbon emissions. As key components of this grant proposal, AquaShares would try to make an invisible resource explicit, and seek in a study to analyze and answer the following questions:

- Can groundwater well owners or their agencies realize economic value by reducing pumping in aggregate across their basins?
- If so, what is the most efficient mechanism for doing so to maximize this value across the three sources listed above?
- Does this economic value create an additional incentive that ensures well owners will comply with pumping curtailment requirements in their basins?
- How can a pilot program in a California groundwater basin be structured to demonstrate these points?

In a larger political sense, the study could test the value of whether, and how, California's system of cap-and-trade emissions credits could be leveraged and adapted to 'prime the pump' of emerging cap-and-trade groundwater credits. If successful, the grant could help simultaneously speed up both climate adaptation and carbon mitigation, combining the interwoven healing of earth and sky.

Correspondence with Author of Study on Carbon Embedded in Groundwater

Wood, Warren <wwwood@msu.edu> wrote:

Hi Jamie;
Thanks for the e-mail as I am always keen to chat about my research and will attempt to address your questions:

If groundwater recharge and discharge were at equilibrium steady state (rate not changing with time) the amount of groundwater recharged would equal the amount discharged and the CO2 released by the discharge would be the same as taken up by the recharge. In a non- equilibrium state groundwater of depletion condition more groundwater is discharged to the atmosphere than recharged thus, you have more CO2 released to the atmosphere than is taken up by the recharge. That is the net amount added to the atmosphere is greater than removed. The reason this is important is the large volume of water stored in groundwater and thus, **its long residence time of tens to thousands of years**. It is relatively unimportant with rivers and lakes as the residence time is only a few days or months.

The reason we used half of the bicarbonate is that **in most aquifer systems half of the bicarbonate ion comes from CO2 gas and the other half comes from the dissolution of calcium carbonate (mineral calcite and the rock limestone). In this study we were only interested in the CO2 component thus we counted only that part.**

Hope this response is of some value to you. I would be glad to chat with you any time. I am not familiar with your book but the title is intriguing!
Cheers,
Warren W. Wood Ph.D.
Visiting Research Professor of Hydrogeology
Department of Earth and Environmental Sciences

____

- As a non-geologist/hydrologist, I'm unclear (and debating a colleague) as to whether -- and if so, why -- is is only "*depleted*" (aka over-drafted) groundwater that would release carbon, rather than the larger volume of *all* groundwater that precipitates, slowly percolates through the earth and is eventually again brought to the surface and used? Is it a function of time -- the decades/centuries in which essentially "carbonated" water has marinated in the substrate, whereas "fresh" atmospheric rain/snow doesn't have a chance to stew before it's brought to the surface?
- Also, why did you and your co-author only count half the bicarbonate as being released, instead of all of it?The difference in California (which represents 1/3 to 1/7th of America's depletion) would of course be tremendous; you may already be engaged in further study of the extent of the hidden dynamics you have recognized and brought into the light, so to speak!