Watropy - Shifting the water paradigm

Synopsis

Entropy, that obscure concept underlying thermodynamics, had immense practical implications. It says that energy has two dimensions, quantity and usefulness. Watropy is an analogous concept saying water has two dimensions, quantity (litres) and useful life (time). This article shows that this possibly equally obscure concept has immediate practical implications which could have a profound impact on how we manage water. This article, following the irrigation conference in Brisbane, looks at the technology of watropy and the problems of changing paradigms in the water industry.

The conference and the water crisis

Anyone who attended the Irrigation conference in Brisbane could not have failed to catch the sense of urgency to resolve our water problems. It started with Campbell Newman, Lord Mayor of Brisbane saying that our water management was dysfunctional, no new infra structure had been created for some twenty years, with 50,000 people entering the region per year the demand for water was increasing, yet with the current drought the supply of water was decreasing, creating crisis conditions.

Many speakers honed in on climate change saying we could not look on the current drought as an exception but had to plan based on this becoming the norm. This theme of water crisis went right through to the last session on the problems of urban irrigation and what this meant for our lifestyles.

Yet once the rhetoric had died down where were the solutions? Plenty of fine tuning at the edges! How to improve the distribution efficiency of sprinklers etc but nothing that was going to solve the problem. Yet as was pointed out we receive almost a million litres of rain per person per day, the amount of rain that falls on our cities exceeds the water use and yet we only catch in our dams 1 in 2,000 of the litres of rain that falls.

How do we resolve this dichotomy between our very real water shortages and the large rainfall per person?

Shifting the water paradigm

We could look at this from a simple technical level and talk about our high evaporation from our catchment areas, we could look at it from a political level and talk about the over allocation of water, but these approaches do not get to the heart of the problem, which is really how we think about water.

We live in a dry country, yet our thinking and technology is derived from countries with higher rainfalls and lower evaporations, so how do we go about challenging our thinking processes? To do this we have to talk about paradigms and how they are changed. Paradigm implies communal intelligence, with the concept of some group, organisation or community having a commonly held view. We can talk about a water bureaucracy, an amalgam of water authorities, councils, governments, universities, CRC's etc which combine to manage our water resources and which hold a generally accepted way of managing our water resources: - the current paradigm.

The process of paradigm shifts is well understood. The current holders of a successful paradigm will hold onto that paradigm and strongly defend; - *it if it is working well*. Paradigms are only challenged when dissatisfaction with the current paradigm sets in. Typically the new paradigm may involve extra expense and complication. Building dams and feeding water under gravity and dumping waste to the sea is a very cheap way of managing water. The alternatives such as recycling, desalination etc are expensive and complex. Change will not occur unless there is dissatisfaction that the current paradigm is not delivering. The different positions were well illustrated at the conference.

Dissatisfaction with paradigms - east and west

Speakers from Perth were saying they have experienced gradually lowering rainfall over decades; predictions are that climate change will result in Western Australia receiving lower rainfalls; they are accepting that this is not some drought as a result of the typical Australian weather cycles, but a major change in the system. They were not saying that climate change was proven, simply that they had to make the assumption that climate change was happening and they had to work out strategies for dealing with the lower rainfalls. They had made this jump by saying we are dissatisfied with the current paradigm of managing our water and have to change the thinking; the stage for a paradigm shift is set.

Interestingly the maps of climate prediction showed that South East Queensland was the other region in Australia that would suffer from lower rainfalls. Yet the views of speakers from this region fell into the defenders of the old paradigm. Yes we can manage by tweaking the current system, more of the same, build more dams, impose tougher water restrictions, improve irrigation efficiency etc.

There is an almost Monty Python logic here, our dams are almost empty so lets build more dams. There is still satisfaction with the current paradigm so conditions are not right for a paradigm shift.

But dissatisfaction is only the first step in a paradigm shift. What do studies of paradigm shifts say about the next stages?

Rarely do changes come from within. Corporate culture suppresses the views and thinking of people within the culture. We see many examples of individuals who may hold private views contrary to the views of the corporate

structure. But these views are swamped by the overwhelming corporate culture and the pressures to conform on potential whistle blowers are great. These large and powerful organisations employ highly intelligent people with major resources to defend the current paradigm against all attackers; - inside and outside.

The new thinking or paradigm tends to come from outside the organisation, what is often called the entrepreneurial thinker. But rarely do these external thinkers have the resources by themselves to influence or challenge the power of these organisations. The normal process is that these external thinkers influence individuals within the organisation who then become intrapreneurs.

It takes a great deal of courage to be an intrapreneur, but if conditions are right, i.e. dissatisfaction with the current paradigm; they may just have the respect, resources and expertise within the organisation to effect change. If successful they achieve a meteoric rise though the organisation, if they fail they are dammed as troublemakers and their career is challenged.

With water we need a paradigm shift, a major change in the way we think about water. Maybe we should slow down a bit and have a long cool think about what is happening with water.

The need for a paradigm shift

The heart of the problem appears to be that everyone in the water business is so frantically active that there is no time to just sit and think. One of the interesting quirks at conferences is that before you make any comment you are asked for your name and affiliation. Where do you come from and what is your agenda?

Now I do not have any affiliation, I have been fascinated by water for over sixty years. As a kid I built my first dam in the local creek. In my professional career, as an engineer in the area of computational fluid flow I have been at the cutting edge of changing paradigms. I understand the processes that are necessary for new thinking to be adopted and know how strongly entrenched organisations will hang onto their traditional paradigms even when it is obvious they have been superseded. Now in my so called ‘retirement’ I have the time and independence to take one step back and think about water at my leisure, without having to worry about the pressures that come from working from within an organisation with its own agenda.

And what I see is the urgent need to challenge many or our traditional paradigms about water and replace them with a new set of paradigms more appropriate to our times. Paradigms are not about some gizmo or water saving gadget, they are about concepts, a way of thinking, and that is why they are so difficult to change. How do we go about thinking about the new paradigms for water? Water is just one of our key utilities; energy is another, which has, to date, received far more technical scrutiny than water. What can we learn from energy?

Energy and the Entropy paradigm

The early scientist and engineers quickly worked out ways of measuring the quantity of energy, but then realised that energy had a second dimension, that of usefulness. A unit of energy could heat a swimming pool by one degree, not really very useful. The same amount of energy could heat a smaller quantity of water to make 500 cups of tea, a bit more useful. The same quantity of heat could be used to transform a smaller quantity of water to make low pressure steam to drive a chuggy old piston steam engine which could generate limited power; even more useful. The same energy could transform an even smaller quantity of water to very high temperature to drive a high pressure turbine to make a much greater amount of power; more useful still.

Energy clearly had two dimensions, that of quantity and usefulness. Engineers and scientists needed a way of thinking about this second dimension of usefulness and so the concept of entropy, with its strict mathematical definition in terms of temperature came into being. Now entropy does not really exist, there are no shelves in the supermarket for buying little bags of entropy. It is purely a concept but one which has had enormous impact in the efficient generation of energy.

Why our dams are so inefficient

We have this apparent dichotomy, a million litres of rain per person per day, yet chronic and escalating water shortages. Perhaps if we understood this dichotomy we may be on our way to developing the next water paradigm. For every 2,000 litres of rain that fall we only catch 1 litre; 0.05%. An interesting observation on the Conference was that the focus was on how to make better use of the 1 litre we do catch and the 1,999 litres that gets away were ignored. Perhaps thinking about these 1,999 evasive litres may help develop our new paradigm.

There are two reasons why our dams only catch such a small proportion of the water that falls. The first reason is simple and obvious, which like many simple and obvious reasons is just a red herring. In Australia we are extremely lucky in having a large land mass where we can allocate dedicated areas to catching our water. Very few countries have that luxury. The land area in our catchments is only a small proportion of the total land area, so all we have to do is to increase our catchment area and build more dams. Right?

We have set aside areas, just to catch water for our cities. If we think climate change is for real we should set aside at least twice the area of land for catchment. Well that is the old paradigm speaking.

If we collected all the water that fell in our catchments we would have plenty of water, but we don't. We only catch a small percentage of the rain that falls on our catchment.

Why is it that we only catch such a small proportion of the rain? The heart of the matter is that Australia is mostly a hot dry country. This may seem such an obvious statement yet much of our thinking on water is derived from the cold and wetter Northern hemisphere which has not just more rain but much lower evaporation levels.

By the time it does rain the soil, at least on the surface, has dried out. It typically takes some 50 mm of rain to saturate this surface soil before there is any run off. This is why droughts are so devastating for us. It is not just that there is less rain, obviously there is less rain but often not that much less rain. It is simply that the rain that does fall is absorbed by the surface soil with no run off. The rain is simply less useful. It takes a large rain, preferably spread over several days to wet out the soil and to get runoff into our dams. We have the rain but it is not useful.

The simple fact is that most of the rain that fall on Australia is simply lost by evaporation before doing any useful work.

Watropy - the useful life of water

Like energy, water has two dimensions, quantity and usefulness. Our current paradigm is focused on quantity; the new paradigm should focus on this second dimension of usefulness. We could call this second dimension 'watropy' a measure of the useful life of water.

Drought and the threat of climate change are so scary because what rain that does fall is less useful. The actual rainfall may only drop by 20% but because of the higher evaporation we may only get half our normal run off into our dams. It is not just that we have less rain; it is that the rain is less useful. Droughts and climate change do not just mean less rain they mean less useful rain.

We need to think about the usefulness of rain, how can we put the rain that does fall to better use?

It is an interesting observation that we may only catch between 10 to 20% of the rain that falls, as the rain falls onto the dry soil in our catchments. The rest simply is absorbed by the soil and quickly evaporates. The problem is not so much too little rain but an excess of evaporation.

The areas of our catchments and our cities are roughly the same and therefore receive the same amount of rain. But in our cities the rain falls mainly on hard surfaces and runs off without being absorbed by the top soil and lost to evaporation. It is potentially more useful but we need to work out how to turn this potential into reality. This is do-able but takes a bit of thinking about.

This is why we need to slow down and think through a sensible integrated water strategy before launching into frenetic activity building new dams so we have even more 'almost empty' dams.

The water crisis is real and we have to act, and act quickly, but just launching into a repeat of the past may not be the solution. What is that old joke about a wise man and a fool? They both make mistakes the difference is that the fool keeps on repeating his mistakes. If solving the water crisis was just as simple as building a few more dams, fitting low flow shower heads and converting from flood to drip irrigation ,then it would have all been done by now. It is a difficult problem which requires some serious thinking, not some quick superficial knee jerk reaction just because everyone is too busy to think.

But how to start that thinking!

Our dry but vegetated land

Just taking a drive out to the bush is as good a place as any. How many people, let alone our water managers have just sat in the bush and wondered how it all works. It is really quite amazing; in many parts of Australia evaporation far exceeds rainfall. The farther inland, the wider the gap but even in the middle of the Simpson Desert with only a hundred or so mm of rain (when it does rain) and an evaporation of about 3 metres there is still vegetation. It is not just some barren plain with nothing growing. How do the plants manage to survive?

The superficial answer is that the plants are highly specialised with such adaptations as deep roots, waxy or thin leaves, the capacity to sacrificially shed leaves and even limbs to save water. All true but without the fundamental physics of water nothing would live.

Look at the mechanics. At some point in time one of those random storms will blow in giving a good heavy rain. The ground is full of seeds just waiting for such a rain and within days the whole place is covered in vegetation. But soon the blazing sun is back and most of the plants will simply die.

The survival mechanism of the smaller plants is to seed before the soil dries out. These seeds can survive without water waiting for the next rainfall.

But the larger trees have a different survival mechanism. Some (or most) trees are sacrificial, they put down roots into the ground when there is water available but then most trees just die off, leaving their dead roots to be eaten out by ants or just rot. Deserts are just full of dead plants and trees. But these dead roots leave small channels down deep into the ground so when the next rain comes along the water is not just caught on the surface tp be lost by evaporation but soaks deep into the ground, protected from evaporation.

Deserts may appear to be covered in sand but often that sand is just a covering with layers of clay or rock underneath. When the water hits these impervious layers it will start to flow horizontally and may form pools of subsurface water. Protected by the ground above, these will have a long life supplying water to the few plants which do survive.

This requires a certain fortunate geological structure, if this does not exist, as in our stony deserts, then even our toughest plants with all their defence mechanism can't survive, simply nothing grows, it is barren.

Gizmo's and concepts

Urban irrigators could simply imitate this process by boring a hole near a tree, and working the soil to direct any rain into the hole. Undoubtedly this would work and maybe the trees may never need to be irrigated again. Good stuff - but we are not going to solve the water crisis by boring a few holes and making a few channels in the ground. We have to get past this gizmo stage which will only make a marginal impact on the water crisis. Instead we need to develop basic concepts or principles which can be applied widely to solve the water crisis.

Unfortunately paradigm shifts are about adopting concepts not gizmos, one of the major difficulties in getting a paradigm shift accepted is that people, particularly people under pressure will see the gizmo, which they may accept, but miss the underlying concepts which provide the real solution.

So let's go back to the desert and have another look at the mechanics of why plants quite happily survive in regions where evaporation far exceeds rainfall. There are three basic principles.

The first is amplification; water is caught over a large area and funnelled into a smaller area, effectively increasing the nominal rainfall. This land where noting grows I sacrificial allowing a smaller are to be productive. Cities are just full of the equivalent 'dead' land where nothing is growing.

The second is transport. Water is transported first down into the ground then horizontally by subsurface flow.

Thirdly is subsurface storage. Water is stored under the surface away from direct evaporation, shielded by the dried surface crust.

There is many times more water stored in the soil than all our dams combined. Storing water in the soil is the cheapest and most effective way of storing water. It is why rivers flow long after the last rain.

Useful life of water

Amplification, transport and subsurface storage are useful engineering principles which we can use in specific applications, but they do not form a fundamentally new concept which leads to the required paradigm shift. But let's go back to our early example of energy which has two dimensions; quantity and entropy. Water again can be thought of as having two

dimensions; the first quantity is real, measured in litres, while the second is conceptual and is 'useful life' which can be measured by time.

At first the concept of water having a second dimension measured in time may seem abstract with little practical application, until we realise that this is exactly what we are doing already with our system of dams. Dams make no difference to the quantity of water, it is still going to rain, there is going to be run off which will flow into our river systems. If we had the luxury of a steady rainfall, we would not need dams; we could just use the water straight out of the river.

Our climate is highly variable so we use the dams as storage devices so the water is available when we need it. We have not increased the amount of water, we have simply made it available when we need it; we have extended its useful life. In their natural state, without dams, many rivers in Australia would simply dry up for much of the time, with isolated periods of high flows and flooding.

We could describe our systems of extending the useful life of water using dams as 'macro harvesting', and by contrast the natural system of harvesting, as has been happening in our deserts for millions of years, as 'micro harvesting'.

Many techniques such as percolation holes, leaky dams, twin dams, and wicking beds have already been developed based on the three basic principles of amplification, transport and in- ground storage. These have been well published and are described on the web site www.waterright.com.au.

Peter Andrews in particular has utilised these basic principles to successfully demonstrate the effectiveness of micro water harvesting. His work has received wide spread publicity in the TV program Australian Story and there can hardly be a person in Australia with an interest in water who is not aware of his activities (and struggles).

So where does micro water harvesting fit into a total water strategy.

Comparison of macro and micro water harvesting

Macro harvesting, capturing and storing water in dams extends the useful life of water to a number of years. It is big time, requires large amounts of money, land and resources but delivers large volumes of water when it is needed at a very low cost (on a per litre basis) at high quality. The mega projects are managed by Government entities.

Macro harvesting only captures a very small proportion of the water that falls on the catchment areas which in turn are only a fraction of the total land area. Hence our capture rate of 1 in 2000 capture of total rainfall. But the immediate concern in these times of current drought is that as the rainfall drops the proportion of water harvested drop disproportionately. When the upper soil has dried out it takes a minimum amount of water before there is any run off. Dams work well when there is plenty of water but rapidly become ineffective as the rain fall drops.

Micro harvesting is almost the opposite in every respect. It is essentially small scale and low cost, a tiny backyard, street or hamlet, a local park or small scale horticulture can use the technology. In theory large farms could too, but no farmer is going to change while cheap irrigation water is available. It is not limited to catchment areas so can gather water not normally available to macro harvesting but most importantly it can gather water from very small rains without having to wet up the soil before there is any run off.

While each individual site may be very small it has the potential to capture very large volumes of water, much more than we catch in our dams and makes use of the 1,999 litres that get away, wasted to evaporation.

Micro harvesting can extend the useful life (time before more water is needed) of rain from a day or so (for shallow rooted plants) to 30 days, and much longer for deeper rooted plants but it cannot complete with the useful life of water in our large dams (when they are full).

It may appear that traditional dams have all the advantages cheap, clean water with a long useful life. Absolutely true; - as long as there is plenty of water to go around.

Micro harvesting can never replace traditional dams, what it can do is substitute water which is currently being taken from our dams. It is a complementary technology. There is no question that micro harvesting should be widely promoted and adopted as part of our strategy of surviving the water shortages.

Just as in the energy world we have small amounts of high grade energy used for power generation and large amounts of low grade energy used for lower grade needs with water we have small quantities of highly watropy (long useful life) and large volumes of water with a lower watropy (shorter useful life). Yet, at least in our cities we have traditionally focused on the high watropy water from our dams (although the concept of cascading use of water by recycling is now accepted) and ignored the large volume of lower watropy water which largely just goes to waste.

The process of change

Micro harvesting has received so much publicity and all the States and Federal Governments are aware of the technology but have taken the option of no action. We have to ask why? To answer this question we have to look at the mechanics of change.

We know that the first requirement for a paradigm shift is dissatisfaction with the current paradigm.

Many people still have not reached this stage of dissatisfaction; they argue there are still large areas of land potentially available for further dams and there are also the technologies of recycling and desalination. They say it is still

technically possible to continue with our current paradigm; - staying with the macro approach, undertake more mega projects, new dams, recycling plants and desalination plants. But there is always a human, social and environment cost.

But when, at the conference, you hear the Lord Mayor of Brisbane using words like dysfunctional to describe the way we are managing our water then maybe the first phase of change, dissatisfaction with the current paradigm, has already occurred.

Even if there is dissatisfaction with the current paradigm there are still many steps before the paradigm shift occurs.

The next stage is the process of gaining wide spread acceptance of the concepts of the new paradigm. This is not the same as adoption, just because many people accept that need for change does not mean it will happen. Acceptance of the need for change is a prerequisite for the next stage of actual adoption.

Generally there are three types of people participating both positively and negatively in this adoption stage.

At the bottom of the conversion list are the 'crusties', these are totally opposed to change of any sort. They just hang around and grump throughout the process of change but once change is underway they cannot halt change. These are the blockers.

Next level up are the 'puddings' who tend at the intellectual level to agree with the need for change, but do not participate in the process of change they will wait passively for the change to occur around them. At some point they recognise that change is inevitable and is occurring around them and it is now 'safe' for them to adopt the new paradigm, when they will make a rapid conversion.

'Puddings' are by far the most common and their rapid switch from the old to the new is why change seems to be in the air almost for ever then suddenly change happens, seemingly almost overnight.

Next level are the 'hunters', those people within the organisation who are actively looking for change, seeking it out wherever it may come from.

If they find the seeds of change they become disciples of the change and may promote the new concepts within the organisation. These are vital for the process of change, as those outside the organisation have no capacity to make the change but instead have to rely on the hunters or intrapreneurs. But 'hunters', working for a large organisation will not always create the change, they have to weigh up their personal risks. If they asses the organisation is ready for change and they can tip the barrel they will run the risk of sticking their neck out and if they are successful in creating the change within the organisation they will become heroes almost overnight.

However, if they fail in making the change within the organisation they have to suffer severe consequences. Organisation can be very cruel to the whistle blowers and trouble makers who unsuccessfully call for change.

Just because there is a need for change and the new course of actions are available and known to the 'hunters' does not automatically mean that the 'hunters' will become the active organs of change. To understand why, we have to look at how organisation work and the meaning of communal intelligence.

Communal intelligence

Communal intelligence is more than the sum of the intelligence of all the individuals within the organisation. Organisations have an intelligence of their own. At first the concept of an organisation having an intelligence or a mind of its own is challenging.

Modern society and the issues its faces are so complex that it is impossible for any one individual to have all the knowledge required for a solution. That is why we have organisations so people can work cooperatively together. Individuals are involved in the processing of bits of information rather like in a computer. People rarely undertake work in the classic sense; work is now only done by machines and Chinese peasants. We are all involved in the business of processing bits of information.

Just like in a computer the organisation will reach a conclusion based on the accumulated processing of all the individual bits of information by all the people within the organisation. It is this final conclusion which is communal intelligence. It may sound a bit like science fiction but the organisation develops a mind and will of its own.

Computers have hardware, all the bits and bobs which take the on /off decisions, but they are organised and controlled by software which controls the overall operation of the computer. Hardware does sometimes fail but more often it is defects in the software that cause failure. Individuals within an organisation are analogous to the logic boards in hardware, in general undertaking their specific functions efficiently and correctly. The structure of an organisation is analogous to software, providing the overall control.

Looking back on the history of water it is stunning how many stupid mistakes have been made, and still are being made, by apparently intelligent and dedicated people. But looking at the structure of the institutions that ultimately control water management, that maze of Federal and State Governments, local council, water authorities, irrigation organisation, Universities, CRC's, the CSIRO etc it is no wonder that so many stupid mistakes have been and continue to be made. It is this maze of institutions which the Lord Mayor of Brisbane described, with refreshing honesty and accuracy, as being dysfunctional.

Protecting the organisation

All organisations have objectives and mechanics of achieving those objectives. If someone asked what the objectives of a motor company like General Motors or Ford were the simplistic answer may be to make cars. But a little probing would see that making cars is just the mechanics of achieving the objective or the means to an end. The objective may well appear to be making money for the share holders but again this is still not the true answer. Share holders have almost no ability to influence the decision making process of a major corporation, at best all they can do is vote with there feet and sell their shares.

The ultimate objective of any organisation is to protect the organisation itself. Making cars or delivering water or running a country may be the apparent aim but it is simply the mechanics of achieving the ultimate aim, protection of the organisation. The aim of the political party which happens to be in power is to stay in power and it does this by hopefully running the country well, or at lease appearing to run the country well, in which case it will get elected (at least in a democracy).

Watching the news is often highly perplexing as night after night there is some running story about some large organisation behaving in a totally anti social or unethical way. This makes no sense until the basic truth is realised that the organisation acts to protect itself. That phrase about what is good for General Motors is good for America came from an executive at General Motors, not Ralph Nader.

The aim of the entities which make up that conglomerate which we call the water institution, that collection of political, governmental and private authorities is to protect that entity, which it does by competently managing its contribution to water (or at least giving the appearance of doing so).
If all this seems like some form of paramania just try writing to these organisation and watch the siege mentality at work.

As water becomes increasingly important there is ever greater desire to control the water. An example is the issue of ownership of water. Our States Governments attach great importance to their ownership of water. Partly it is about control, but they also can make a lot of money out of water.

Micro harvesting, water catchment by individuals and small communities is a direct threat to the power and revenue derived from the control of water.

Real change will occur when the populations' attitude to water changes from a passive acquiescence that the States own the water, to the view that water belongs to the people, and the States are custodians of the water for the benefit of the population. It is only when this view becomes widespread and threatens to makes its' impact at the ballot box that we can expect to see major changes to how the country manages water.

Never underestimate the power of public opinion.

Colin Austin 22 May 06