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Ice Storage: A Cost-Efficient Way To Cool Commercial Buildings While Optimizing the Power Grid

When CALMAC CEO Mark MacCracken looks at a building, he sees thermal mass and air conditioning load, and – above all – an opportunity to vastly increase the efficiency of our national power grid. He sees the world of electricity production and consumption from an integrated, systems-thinking approach, and the potential for huge improvements. Which is a blessing and a curse, because alongside the enormous potential, he also observes an impressively high level of old-school, status quo thinking that keeps us mired in uneconomical ways of running our power grid and cooling our buildings.

Here's the problem, and the opportunity: In the United States, according to the DOE, roughly 35% of our electricity is consumed in the commercial building sector. Of that 35%, about 15% is dedicated to HVAC (air conditioning load). So 15% of 35% is not a big deal, right? After all, it's only 5.25% of total electricity consumption. Wrong, and here's why.

That 5.25% is the average over the year. And we don't use our AC at all in the winter, and very little in the spring or fall. We use it when we need it. It's that air conditioning load that contributes the lion's share of additional peak demand on those hottest of summer days, straining our grid and driving us perilously close to the edge on the worst days. And on those hottest days, it represents far more than 5% of consumption. In a place like California, residential and commercial air conditioning can represent over 30% of summertime electric loads.

It's the demand on the margin. And it's that cooling load that causes our country to have to invest in an oversized infrastructure that we don't even need or use most of the time. It would be as if McDonalds had to design their kitchen and size their grills for the few days a year that a school bus full of kids drives up, while the rest of the time, that extra grilling capacity would lie idle.

This is an issue that MacCracken has looked at for over three decades, and he has developed a cost-effective solution to address it: ice storage.

> When I explain this problem now to a group, I will ask the rhetorical question: 'Have you ever thrown a party? Do you think it's a good idea to start making ice cubes when the people start walking in the door?' Everyone knows you couldn't make them fast enough.

MacCracken notes that while the person at the party may only need one pound of ice, to air condition that same person in an the office would require somewhere between 150 and 300 pounds.

> So if it's ludicrous not to make one pound per person ahead of time for a party, why isn't it hundreds of times more ludicrous for buildings to act like they didn't know you were coming, and create cooling when people get to the building? And they do it when electricity is two to three times more expensive than the night before?

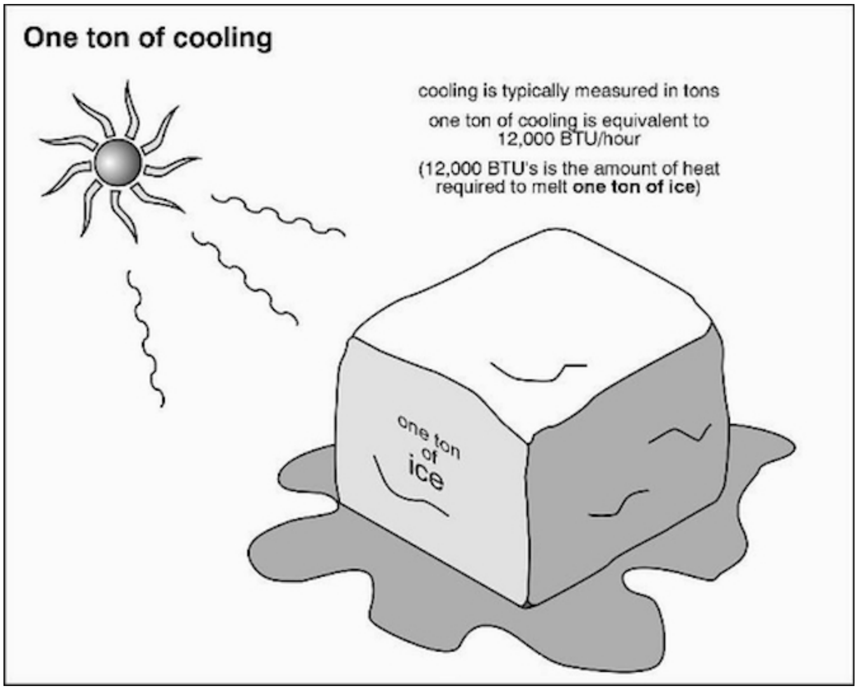

Image: www.neilorme.com

MacCracken observes that the end result – with our increasing reliance on air conditioning – is that we have created a vastly under-utilized resource in our electric power grid: Off peak energy.

> In late 50's early 60's, our load factor was 70%. (author: load factor is another way to describe capacity utilization – 100% load factor would be if we used the maximum capability of the electric grid all the time). But with the advent of air conditioning, that load factor has been going down, and now it's below 50%. That means we have twice the transmission and distribution we need if we used electricity at a level rate day and night. And the last 20% (of our infrastructure) we use less than 2% of the time. And this is all because we haven't addressed air conditioning the right way.

In response to that problem, MacCracken developed a product to cool buildings using ice that is created during the nighttime when the power grid is underutilized. When integrated into new construction, the CALMAC IceBank product also allows one to design a building with a lot less equipment required for air conditioning. Most building engineers overdesign the HVAC system in a building to meet peak load for air conditioning demand – which may occur perhaps 50 to 100 hours in a given year. CALMAC takes a different approach.

> We are designing for the average load, so we can downsize the equipment, run it at night, and use the ice storage during the daytime to help meet the entire cooling load of the building. It's a different way to design a building which is unknown to the occupants but reduces operating costs.

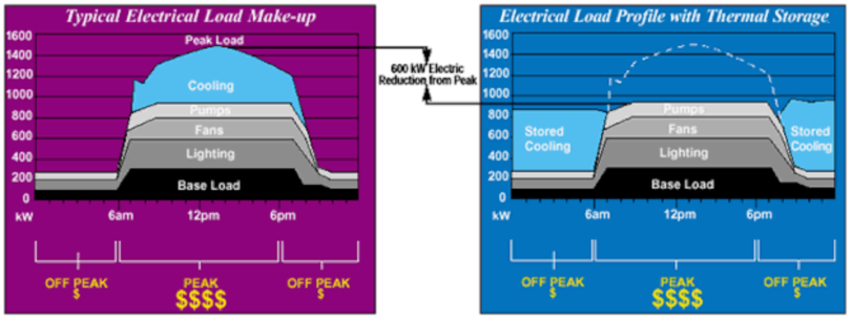

Image: CALMAC

It's a smarter way to do it, utilizing a systems-thinking approach that lowers overall resource requirements.

> On a capital cost basis, in new construction, it really doesn't have to cost anymore, or if it does, the payback is in a year or two. For example, if GSA designed a 1,000 ton building (a house is five tons) the way they would design the air-conditioning system is to multiply peak load by 1.2 and then divide it into three 400 ton chillers to cool that building.

The logic is that the engineers don't know ahead of time if it would be exactly a 1,000 ton building, so they give it a cushion. If one chiller fails, you would still have 800 tons to cover a 1,000 ton building.

> Our system says 'no, put in two, and the money you save on the third chiller, the cooling tower, pumps, and electricity capacity charges, you can now use to buy energy storage tanks.' Now the chillers can run at night and store cooling (in the form of ice when rates are the cheapest), and during the day you use stored cooling to help the smaller sized chiller to meet the entire cooling load.

It's a little different in existing buildings, because you have to deal with existing equipment and infrastructure, but it can work there as well. The key is to wait for the opportune moment.

> Usually, what we do is wait for a driver or trigger to happen. Perhaps the chillers are 20 years old and wearing out, or the refrigerant is no longer being made, or the building is undersized and you need more capacity. Retrofit is where we have to concentrate. Over 80% of the buildings that will be here in 2030 are already built. Rockefeller Center (in New York City) is a good example of what you can do. With Rock Center, we show savings of $1.2 million per year. We did TIAA CREF, with tanks on the 28th floor of the existing building. We had new chillers, and cooling towers with energy storage, all in the same physical space. In St Lucie School District in Florida we were a major contributor to annual savings of $5 million. And we are saving them three-quarters of a million dollars per year. Credit Suisse at 11 Madison Avenue in NYC is another one, saving $1 million a year.

In those cases, retrofitting with ice storage makes sense and yields a healthy return on investment, with paybacks between three and five years. As with all things energy efficiency, most customers won't undertake a project if the payback is over five years.

Unfortunately, there are still plenty of builders and developers that care very little about lifetime efficiencies. Many put the building up quickly and at low cost, with the intention of flipping it within a short time frame, so they are unwilling to make the upfront investments.

> LEED certification, or similar sustainable design processes, are helping to change that, but if it's a spec builder, it's still very, very difficult. If it's owner-occupied then it's a little easier. We have lots of corporate headquarters where they build and stay in it, and look longer term at operational costs.

To make matters worse, some of the current practices and economic incentives mitigate against any significant level of intelligence and lifecycle cost analysis being applied to the process of design and construction.

> Engineers are sometimes paid based on the mechanical cost of building, and they get a percentage of costs, and if the product doesn't add to the cost, they don't make any more money. They tend to avoid ice storage unless there's a driver – namely an owner that says 'hey, I care about operating costs.'

MacCracken also notes that the confusing structure of electric rates doesn't help much either. He refers to it as "the mystery of electric rates."

> Most (commercial) people look at electricity and assume it's like their home…That's absolutely false in commercial buildings. And utilities don't tend to help clear that up – they make a lot of money during peak days. When the utility has a "flat" energy rate which includes a demand charge, it's the same as time of day rate. The facts are there, but it is confusing, and most engineers who look at electric rates throw up their hands and don't recognize the major difference between day and night power costs.

MacCracken has a point. Most of us don't think about power and how volatile or different rates can be. Let's take gasoline. Imagine if you pulled up to the pump and saw a sign saying $3.50 a gallon during the daytime, and $1.19 from 10 PM to 7 am. And what if you paid an additional charge only during the day based on the size of the tank in your car? That is somewhat how electricity is priced, with its own internal logic for doing so. It makes sense to the system planners, but few consumers understand it. Regardless, the fact is that nighttime power is usually far cheaper than daytime power, and has been so for some time. Which is why making ice at night to cool a building during the day makes sense.

> The Edison Electric Institute once stated that the only form of energy that hasn't gone up in pricein the past 40 years is off-peak electricity. If you separate the cost of on-peak and off-peak, off-peak has stayed the same. So the smartest thing you can do – historically speaking – is to design your building to utilize off-peak electricity.

Making ice at night is one strategy for doing just that. MacCracken expresses frustration at the barriers, but he can also point to numerous other successes in recent years.

> In the Philadelphia area, we have a project at 1500 Walnut St where they are working with Viridity and playing the synchronous reserve market. (author's note – providing a resource within a short timeframe to help stabilize the power grid. The cooling system can essentially shut off with a few minute's notice and – by not using energy at that point – help stabilize the grid in the short-term). There are more revenue streams that are available for the more sophisticated owner.
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> In New York, they just put in an incentive for almost $3,000 per kilowatt for peak load reduction… In New York City in the last five or six years we did the new Bank of America Tower at One Bryant Park, the Goldman Sachs world headquarters, the New School building and about a dozen others in NYC.

At the end of the day, this is all about systems thinking: how to do things most efficiently within the context of electricity economics. It's cheaper to 'store' the electricity needed in the form of ice than it is to use batteries or pump storage, (pumping water up a hill at night and running it through generators during the daytime when electricity costs more) where you have efficiency losses of up to 30%.

> Pumped Hydro is a useful technology because it can be used to deliver electrons to the building to run lights and electric motors that need electrons. However, it makes no sense to use pumped hydro to run a compressor on-peak to cool a building. It's a lot less expensive and more energy efficient to store cooling, in the form of ice.

Looking forward, MacCracken sees more need for ice storage in the near future as the amount of wind and solar resources on the system increases.

> A tremendous amount of storage will have to be added to the grid because there is essentially none on it now . Lots of renewable energy needs to be stored so it can be dispatched when it is needed. Look at net zero buildings as an example. If you have a green building off grid, I guarantee you there will be a lot of energy storage available within that off-grid entity, including batteries, stored heat, and cooling. Taking two wires and connecting that building to the grid doesn't make these issues automatically disappear. Net zero just outsources the storage problems to the grid which basically has none.

MacCracken is an industry veteran, with 37 years in the pursuit of getting people to do things smarter, more efficiently, better. And he is still amazed at what it takes to change a mindset.

> We have over 4,000 projects around the world and a dozen projects we can take people to and show them in NYC. When selling, they make you walk through glass sharded rooms for two years to convince them, even though we have existing projects to take them to, and people speaking positively on our behalf. Then, once it is in and operating, they are as happy as can be. It is like "Why is this so hard?" So now we focus on selling the CEO and CFO and say 'do these financials work for you?' Forget about the technology. If we get a yes on that, then we meet with the technical people and take them to five great projects that are saving money. And yet it still takes time.

He's optimistic that the new incentives in New York may finally get people to change. And he is convinced that, as we move increasingly towards a renewables world, ice storage can have a major role. He points out that you cannot put a lot of wind or solar in a dense urban environment for technical reasons. But you CAN turn that urban environment into a massive energy storage repository, using ice.

> The urban part of the renewable solution is the storage of the energy, not the collection, and it's the logical place – you want to store it at the building where you are going to be using it.

MacCracken is also convinced that his technology can play a key role in this equation. After all, he has spent the last 30 years proving up the value proposition.

> Over the years, we have developed a bullet-proof product that will outlast you and me, with a 50-year life. This product is a proven and reliable product that is critical for low carbon buildings and saves money for the customer. It should just be part of the building.
