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Comparing Skyscrapers and Schools

By **Bill Holmes, P.E.** June 29, 2012 01:38:12 pm

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A year or so ago I saw the results of EPA's First National Building Competition. I had become aware of the competition when I read about it in the Steamboat, Colorado newspaper in 2010. According to the newspaper story, the Crystal River Elementary School in Carbondale, Colorado was competing with a Manhattan office building and a number of other buildings around the country to see which could save the most energy. Included in the article was a quote from an EPA spokeswoman who said, "Whether it's a skyscraper in Manhattan or a school in the mountains of

Colorado, they aren't fundamentally different." Well, both buildings do have walls, windows, roofs, occupants, lighting and heating and air conditioning systems. Jet engines, industrial plants, schools and skyscrapers all operate according to the same laws of physics. Other than that, she couldn't be more wrong.

I've been involved with designing HVAC systems for the Hartford Steam Boiler Building, a "skyscraper" right on the Connecticut River in downtown Hartford, as well as those in a couple of multistory VA hospitals near New Haven. I also ran 20 buildings in a school corporation for 10 years and reduced their energy consumption and costs by 35%. So I actually do know a little bit about these types of buildings.

EPA's original statement obviously got my attention. So I looked up the Building Competition and Googled the skyscraper, the Morgan Stanley Building at 522 Fifth Avenue in New York. According to the information I found, it's a 23-story, 590,000 square foot building with an electric chiller, ice storage plant, glycol and chilled water systems, pumps, cooling towers and dry coolers, all with large electric motors. The 24-story Hartford building had essentially those same systems.

How a Skyscraper Works

A skyscraper has different cooling requirements in different areas and all at the same time, so you can't just put in an air conditioner with a thermostat in the living room like you can at home. The exterior of a skyscraper needs cooling at some times and heating at others depending upon the outside temperature, wind and sun. When the sun hits the east windows in the morning, the east offices may overheat and need cooling, even in the middle of the winter. As the sun moves across the sky during the day, the rooms on the sunny side may need cooling while the ones in the shade will need heating. A very sophisticated HVAC system is required with complex controls to keep everyone in a large building comfortable at the same time; which according to the Guinness Book of Records, last happened in Minneapolis on March 23, 1982.

Think about it. Have you ever been in a conference room that is burning up or freezing or alternating between the two? Or sitting in an office in the middle of the summer and noticed that the heat is blasting your legs from that little radiator running along the windows? How many times have you had to change seats in a restaurant because a cold draft was hitting you in the face or blowing down the back of your wife's dress? Who doesn't take a jacket or sweater with them to the movies even on the hottest day of the summer? My profession has pretty much completely failed at keeping people comfortable in large buildings. It is my profession and I admit to being a failure; guilty as charged.

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Author Bio



Bill Holmes, P.E.
Bill Holmes, P.E. founded Holmes Energy LLC www.holmesenergy.com and developed the AutoPilot Monitoring-Based Commissioning (MBCx) System in 1979. He has a B.S. and M.S. in mechanical engineering and has done additional coursework and research for his PhD. He is a former Purdue professor and taught for several years in the Continuing Education in Energy Management Program at the University of Wisconsin.

Bill has produced savings from 20% to, in a few projects, more than 50% from low-cost, no-cost changes in management, operation, maintenance and control alone in all types of facilities including Industrial Plants owned by Fortune 500 Companies.

He is the recipient of a DOE Award for Energy Innovation and was the Indiana Energy

Anyway, back to comparing a skyscraper with a school. I've described the exterior zones of a skyscraper. Now think about the inside or interior zone. The interior of a skyscraper basically has the same cooling load all day long, every hour that it is occupied, every day of the year, summer and winter. It could care less what is happening outside. It never needs heat, only air conditioning to remove internal heat generated by the lights, the people, the computers, copy machines, coffee pots and so on. A big skyscraper in Manhattan has very complex mechanical systems, difficult to modify without screwing things up more than they normally are.

How a School Uses Energy

I was living in Steamboat Springs, a little over a hundred miles from Carbondale. Living at a similar altitude with similar temperatures, I understand what is required to keep a school comfortable in the mountains of Colorado. After reading the article, I decided to drive over to Carbondale to take a look at the school. I was really fascinated to think of an elementary school in Colorado that was fundamentally the same as a skyscraper in Manhattan. I wanted to see it. As I got within 20 miles or so of Glenwood Springs, where the bicycle path follows I-70, I started scanning the horizon. I thought a 23-story elementary school should be visible for quite a distance. When I exited on Hwy 82 and headed through Glenwood toward Carbondale, I still hadn't spotted it. I was beginning to think I had the wrong town. How could I not spot a skyscraper when the tallest buildings in the downtown were only a couple of stories? I actually had to stop at a volunteer fire station to ask directions. Talk about embarrassing.

From its name, I had expected Carbondale to be a little dirty old mining town with a vintage elementary school, like a number of mining towns I have been to up in the mountains of Colorado. It turned out to be a beautiful small town and the Crystal River School is a gorgeous, new, modern brick facility with massive, snow-covered mountains in the background. It was only two stories though. I'm not sure what the EPA was talking about. It sure looked a lot different to me from the photo of the Morgan Stanley Building on Fifth Avenue.

In general, a school has people, lights and in Colorado, needs a really good heating system for those minus 30 mornings. It doesn't have interior zones that need cooling all year around. Most of the rooms are exposed to outside conditions. I don't have an air conditioner. I don't need one. During the summer, in the middle of the day, the outside temperature may reach 75 F or 80 F so we actually do what people in that skyscraper can't – we open our windows. We can open the doors, too because there is no humidity and there are almost no insects. You do have to beware of bears in the evenings, though. Really, I'm not kidding. They're all over town. They come out to scavenge for food. But in a school in the daytime? For cafeteria food? No way. No bears; not a problem. Our summer doesn't really get started until most of the snow is gone and the flowers bloom; around the middle of June. That varies according to elevation. It starts to get cold again around Labor Day. It's never warm at night, no matter what month it is, so all buildings start out cool in the mornings.

On a normal school day, there is not a lot of need for air conditioning. According to climatic data, the average highs and lows in Carbondale for May are 68 & 28 and 75 & 41 in September. Not exactly Manhattan in July. Maybe the offices need a little air conditioning from time to time, and to be able to adjust a thermostat. So even if there is some need for air conditioning on hot days, I can guarantee that the systems in the school 'bear' little similarity to the HVAC system in the skyscraper in Manhattan. The Crystal River School has a couple of boilers and several packaged rooftop units.

I was surprised to see that it had chillers for air conditioning. If they are controlled right and take advantage of the dry, cool outside air, they shouldn't need to run much. Proper control of this type of equipment is essential to energy efficiency and frequently offers big opportunities for savings. Most smaller schools around here don't have chillers but Crystal River is a big elementary school; according to the article it is 80,000 square feet and has 550 students. The building does have operable windows, but it didn't appear that they are large enough to provide much ventilation. That's too bad. Most of the ventilation comes from the rooftop units.

Big skyscraper in Manhattan, very complex mechanical systems; elementary school in the mountains of Colorado, simple HVAC systems; very different.

Want to save energy in a school? Then run the energy-consuming equipment to match the school activities. Use the ventilation system, the windows and the building mass for free cooling as much as possible and keep the chillers off except for a few hours on the hottest days. Tune up the boilers. When nobody is there, turn off the lights, close the dampers that bring in the fresh air, reduce the classroom temperatures during heating and increase them during cooling. Make sure there are actually energy efficient bulbs in the light fixtures. Install instrumentation to track how much energy the total facility and individual energy systems use every hour of every day. Get the advice of professionals. Work with them to tune up the building systems; make no-cost or low-cost changes in operation, control and maintenance, and track the results with the monitoring system.

But don't do things blindly. I have seen more than one boiler destroyed through changes made to save energy by people without a thorough understanding of the implications of what they were doing. And the cost of replacing or repairing that boiler could be a whole lot more than the savings. It's really not as simple as it may seem.

Manager of the Year in 1990. He has published numerous papers and been making presentations on his projects and methods for more than 25 years. Bill is a sculptor, a writer and a regular contributor to Sustainable Plant.

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As for the skyscraper in Manhattan, that's a tough one. If they get stuck, maybe they should just give the Crystal River School a call. Find out what the school is doing and do the same. Remember, "They aren't fundamentally different."

On second thought, maybe I was a little hasty in my original criticism; other than the things I mentioned, I guess skyscrapers in Manhattan and schools in the mountains of Colorado are exactly the same.

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