The Hudson EcoGrid – A Plan for a Sustainable Community

By Beverly Milestone, LEED AP and Grahame E. Maisey, P.E.

Building Services Consultants, Inc.

POBox 176

Wyncote, PA 19095

beverly@bsc-worldwide.com

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ABSTRACT

The town of Hudson in New York State is embarking on a bold plan to create a sustainable community. As a first step, they are attempting to create an energy grid, or loop, that will eventually allow the community to remove itself from the public electric grid and produce their own energy in a fully sustainable fashion. The energy grid will allow residents and business alike to plug into the grid supplying them not only with electricity, but also heating and cooling water.

The project is in the early conceptual phase and many in the community still need to be convinced of the value of such a far seeing project. The long-term benefits for the community are huge. Moving the building energy systems, sewer, water, transport, etc., toward a sustainable system over 20 years will reduce the community energy requirements by up to 90% and allow utilizing totally renewable resources to power a town eliminates their dependence on electricity produced through the burning of fossils fuels. With fossil fuel prices on an upward trend, this will eventually allow the community members to save huge costs.

KEYWORDS

Ecogrid Hudson geothermal community grid renewable resources energy

INTRODUCTION

The town of Hudson is a small county seat community located on the Hudson River in New York State with a population of approximately 8,000. It is embarking on a bold plan to create a sustainable community. As a first step, the citizens of Hudson are planning to create a renewable energy grid, designated the "Ecogrid", to allow the community to become independent from outside oil, gas and electric and produce their own energy in a sustainable fashion. The initial phase of the grid will allow residences and business alike to plug into the grid supplying them with heating and cooling water as well as electricity. With fossil fuel prices on an upward trend, this will allow the community members to save costs while ensuring a reliable energy supply. The project is in the planning phase and some in the community still need to be convinced of the value of such a far seeing project. The long-term benefits for the community, both small and global, are huge.

Once funding in is place, the essential first step is an Energy Master Plan (EMP), the key planning strategy utilized to bring the EcoGrid to fruition and make certain it will perform from start-up. An EMP will moves a community's energy systems steadily toward net zero energy use and will also reduce the maintenance and operation requirement by over 50% and optimizes the comfort, improving productivity by up to 25%. Every step of the sustainability plan must

meet three criteria: Energy reduction + Maintenance reduction + Productivity improvements. The Natural Step (TNS), is the tool utilized by the EMP to assure long-term success. Each step is performed with an eye focused on the ultimate end goals to make certain the plan remains on track.

BACKGROUND

The town of Hudson is located on the Hudson River in New York State roughly two hours from New York City. It is a small community of approximately 8,000 people of various incomes, with a four block wide downtown area approximately one mile long. There is a county prison south of the river end of the community and there is a river development program at the beginning of the planning stage, at the opposite end, a mile away from the river is a hospital.

Hudson, a once prosperous and quite free spirited town, home to Diamond Jim Brady, the floating crap game and a myriad of brothels in its heyday, had been in decline until the late 1990's when it was rediscovered and became a headquarters for antiques. The main street blossomed once again and people began moving back into the area. However, many of the earlier residents remain, some living in a large low income housing project.

Because of one man's vision for developing a sustainable hotel/conference center/spa situated almost exactly in the center of the town, inquiries began about what the whole of Hudson could do to make it a sustainable community. Initially, a geothermal loop was considered to be the primary energy loop, but as technical investigations proceeded, a hot water loop and an electric loop were added to the essential energy grid. NYSERDA is promoting geothermal heat pumps, but this is generally a dead-end scenario that will reduce the energy consumption by 40% but rely on a massive amount of electricity to run the refrigeration machines (heat pumps).

Hudson has a cold, humid climate that means the winters are long and cold and the summers short, cool but humid. A building energy system is needed that responds to this climate: a radiant heating system will provide the most comfortable heating and will also provide the small amount of cooling. Humidifying in the winter is as important as dehumidifying in the short summer. When we examine the comfort criteria for this climate, humidity control becomes essential year round. While this is usually ignored, any complete plan must take into account all the factors of the situation.

The only reliable year-round humidity control system was developed in New York State at the beginning of the 20th century. When cities began to grow so large that the dairies serving them had to grow along with them, there was such a

huge surge of milk entering the dairy within 2 hours that the refrigeration load to cool the liquid became untenable. A liquid desiccant system was developed to remove the very large latent load from the milk and so allow a reasonable refrigeration load to actually cool the milk. This liquid desiccant system remains the most reliable and efficient method of controlling humidity 100 years later. What was finally settled upon was an energy system that would meet all these criteria and allow for expansion of the system to reach further into the entire community.

A WORD ABOUT TNS

The Natural Step, or TNS, was developed by a Swedish child oncologist who linked the rise in the occurrence of childhood cancer in Stockholm to the rise in the pollution and toxins in the air, water and soil. Basically, it is a system whereby the user sets lofty sustainable end goals, for example, reduce energy use by 90% and use renewable for net zero energy consumption, reduce maintenance by 75%, improve productivity by 25%. Once these goals are in place, the object is to backcast to the current conditions or situation and then aim steadily toward the sustainable goals. Set up a plan of action, in this example, a series of projects that will lead, eventually, to the end goals. Every potential step is tested against the end goals and all the criteria and if a step does not meet every goal and criteria, then it is the wrong step and another

solution must be found and tested against the same criteria. In this way, every step will lead to the goal and the goal will be met. Without the end goal constantly in mind, the end will never be attained.

THE HUDSON ECOGRID

The Hudson climate is described as cold and humid. This means that it is quite cold and dry for a long period in the winter and it is humid in the summer for a long period, but not particularly hot for very long. This climate helps dictate the type of heating and air conditioning solutions best suited for inhabitants of the town.

Since an Energy Master Plan uses The Natural Step as its foundation, this requires that the town set extremely lofty goals for its Ecogrid, therefore, we will be discussing net zero energy consumption. Net zero energy consumption simply means that whatever energy is used or consumed, the same amount is transferred back. There are several routes that energy is consumed; the obvious one is the energy for heating and air conditioning, other energy consumptions are transport, water purification and pumping, sewage treatment and pumping, construction energy use, and maintenance and alterations in buildings and all other services. Zero Energy Development (ZED), is a relatively new term used for community development. Transforming an existing development into a Zero Energy Community (ZEC) is also a relatively new term.

Planning a sustainable community will also need to include other systems such as water, sewage, trash, transport, etc., in the sustainability plan. There is a furniture factory in town with a waste stream that could be a good source of fuel. Currently, the waste costs the company money to be hauled away, but this could prove a symbiotic relationship with the Ecogrid. The prison is another likely potential source for a waste stream recovery. These are areas that have been factored into the plan for future inclusion; however, for the purposes of this discussion, we will only be examining the building energy systems.

The initial Ecogrid is planned to cover a one mile section by four block width of the town, which is most of the town. This will include residential, commercial, municipal and the prison and hospital buildings. The current plan is to begin with a geothermal loop together with a hot water loop and an electric loop. This will provide the basic energy systems for most of the buildings in the loop. The sewer system is a combined system that requires substantial investment to separate sewer and rainwater, which should be considered an opportunity to include into the Ecogrid. The water system requires individual metering, which again should be considered an opportunity to include it into the Ecogrid. Other community systems that require integration into the sustainable energy plans are trash and transport. On a sustainable community level, health and safety is always at the forefront, and so these services should be considered as integral to this sustainable community. It is important to include as many systems as

possible into the initial planning so that future plans do not conflict with each other, but rather compliment each other. For example, trash could be separated and used for recycling, feed, fertilizer, energy, etc. Transport buses could be used for bio-diesel combined heat and power (CHP) systems to provide both electrical and heating peak loads and emergency backups. The Natural Step is a very good framework to use for complete planning.

The planned geothermal loop would provide 100% of the cooling in the Summer and 15% to 30% of the heating in the Winter. The hot water loop would provide 100% of the dehumidification in the Summer and 70% to 85% of the heating in the Winter. The electric loop should provide all the electricity requirements year round.

BUILDING OWNERS RESPONSIBILITY

Once a building is hooked up to the Ecogrid, it becomes the owner's responsibility to provide appropriate, sustainable heating and cooling distribution systems. Standard air condition systems and refrigeration units and heating furnaces and boilers must be gradually eliminated and replaced with more sustainable systems over a period not to exceed twenty years. Standard heating systems are usually hot water boilers with radiators. The temperatures required for heating are 180°F, not an efficient use of energy when lower temperatures such as 100°F can be used for radiant heating. Most homes and larger facilities have window air conditioning units. The only place with large air conditioning

units are the new health center, the hospital and the prison. Standard air conditioning systems generate chilled water at 45°F to both dehumidify and cool the air for summer conditioning. Also, using air for both temperature and humidity control requires more air circulation, and fans use 10 times more electricity than pumps use to move cooling and heating energy around. This again is inefficient when we could pump 55°F water for cooling and 180°F water with small air volumes for dehumidification in the summer, with better dehumidification control.

Radiant style cooling and desiccant dehumidification would provide far superior indoor conditions, but more importantly, are able to utilize low temperature hot water in the Winter and warmer temperature cooling water in the Summer. This leads to 80% less energy consumption in the Summer. Warming and humidification utilizing these systems would provide superior indoor conditions in the Winter for 80% less energy consumption. Also, the energy needed for cooling and heating in addition to the geothermal can be from renewable sources: wood, bio-diesel, solar, wind and micro-hydro. As the individual building systems are made more sustainable, the Ecogrid temperatures could be moved toward the sustainable levels and the Ecogrid could be expanded into more buildings with no increase in capacity required.

HUMIDITY CONTROL

Most systems today rely upon forced air to keep us comfortable. Forced air is a

very poor method of controlling humidity and in most areas east of the Mississippi, humidity is an overwhelming factor in our comfort in the summer, not to mention our health, as pointed out by the persistent growth of black mold found in many buildings today, including some in Hudson.

In Hudson, low humidity in the winter dries skin and mucous membranes. Forced hot air heating, as from a geothermal heat pump, does not add any humidity into the air thereby alleviating none of the problems. With the addition of humidity in the winter, we could lower the heating temperature because we would feel more comfortable.

Think about the old refrain you hear every summer, it's not the heat, it's the humidity. This is so true, winter and summer. By adding humidity in the winter, we can lower the heating temperature and we would feel more comfortable; by reducing the humidity in the summer, we could raise the temperature and feel more comfortable.

In the summer, there is high humidity in Hudson. To compensate for this, most people lower the temperature, however, this does not lessen the humidity, but it does cost more because this is electrical energy, which is a very expensive way to achieve to comfort control. This doesn't make it more comfortable, but the ambient or air temperature is lower.

However, the humidity is really what needs to be controlled. Removing the humidity does not need to involve electric dollars if we use a desiccant type

system to control the humidity. A desiccant system relies on a brine that absorbs moisture when it is concentrated, and when it is diluted, we use heat to dry it so the process can cycle over and over again. The heat generated by the moisture removal can be removed and all necessary cooling can be met with a cooling fluid as high as 62°F. We can also use the desiccant system to add humidity in the winter months thereby allowing the folk of Hudson to lower the temperature required for comfortable heating conditions.

The second advantage to removing humidity from the air in the summer is mold control. Black mold grows in moist, warm environments, exactly like the environments found east of the Mississippi in the summer. Remove the moisture from the air and we eliminate the ideal growth environment for this insidious, costly problem.

PROJECTED COSTS, PROJECTED SAVINGS

Preliminary Community EcoGrid Sizing.

NOTE: These are rough numbers only to be used as a guide only.

Estimating the size of Community, from a tourist guide and a map.

Hudson is about 5,625ft (1,875yds, 1.065miles) from Front St to the Hospital.

The distance between Prison and Cherry Streets is less than 450ft (150yds).

Total Community Loop Length = 2 x (5,625 + 450) = 12,000 feet

Costs of Plastic Piping: 12” pipe = $110/ft ($60/ft installation);

14” pipe = $120/ft ($60/ft installation);

16” pipe = $150/ft ($65/ft inst.);

18” pipe = $200/ft ($70/ft inst.);

20” pipe = $250/ft ($75/ft inst.);

24” pipe = $330/ft (100/ft inst.).

2 pipe installation cost = 1.8 x single pipe installation cost,

4 pipes installation cost = 3 x single pipe installation cost.

Standard Geothermal Heat Pump or HVAC System Refrigeration Sizing:

Hospital - 250,000ft^2 = 1,000 Ton; 4 - Churches @ 100 Tons each = 400 Ton;

County Health Center = 300 Ton; Elementary School = 100 Ton;

City Hall = 50 Ton; Police = 20 Ton; Courthouse = 50 Ton;

Post Office = 20 Ton; Hotel complex = 150 Ton;

Opera House = 50 Ton; Theatre = 50 Ton;

2,000 – 3 or 2 story houses @ 3 Ton each = 6,000 Ton; Towers = 600 Ton.

Total tons = 8,800 tons; diversity factor 70%, peak requirement = 6,000 tons.

6,000 Ton loop x 3 gpm (gallons per minute) = 18,000gpm requires 24” pipes:

2 - 24” pipes = $770/ft cost of piping and installation = **$9.25M**

Geothermal wells cost @ $1200/ton ground source = **$7.2M**

Total cost = $16.5M

Desiccant Style Humidity Control System With Radiant Cooling:

40% air conditioning tons = 2,500 tons, (60% of a HVAC system load is humidity)

Cooling only load = 2,500 ton loop x 2.4 gpm = 6,000 gpm requires 18” pipes. Also hot water requirement for desiccant dehumidification, therefore 4 - 18” pipes (instead of 2) = 2 x 200 + 2 x (200 + 40 Insulation) + 3 x 60 = $1,060/ft = **$12.7M**.

Geothermal wells cost @ $1200/ton ground source = **$3M**

Total Cost of $15.7M ($1M less than heat pump loop)

Community Heating Requirements

7,000,000 sq.ft building @ 25BTU/sq.ft = 175,000,000 BTU/H

7,000,000 sq.ft building @ 40BTU/sq.ft = 280,000,000 BTU/H

18” pipe @ 6,000 gpm and 20 degree temperature drop = 120,000,000 BTU/H

18” pipe @ 6,000 gpm and 40 degree temperature drop = 240,000,000 BTU/H

2 – 18” pipes can deliver 360,000,000 BTU/H with a 20 & 40 degree temp drop

Community Electrical Requirements

7,000,000 sq. ft building @ 2 watts/sq.ft = 14,000KW

7,000,000 sq. ft building @ 4 watts/sq.ft = 28,000KW

Combined Heat and Power (CHP) Plant optimally provides 35% electricity, 45% heat:

28,000WK generation = 120,000,000 BTU heat generation. CHP needs to balance heat with electrical production. This looks like we would be able to balance the loads very well.

Minimizing Costs and Resizing the Loop Piping

From the preliminary costs of the geothermal heat pump and Ecogrid systems, the piping loop is the biggest single cost.

If we change the concept from having a single area of geothermal wells and heating and electric power generation to distributed wells and CHP plants, we can significantly reduce the piping for the geothermal heat pump piping from 2 - 24” to 1 - 18” piping saving $7M, costing only $2.25M, and we can reduce the Ecogrid piping from 4 – 20” to 2 – 18” that will cost $4.3M, saving $8.4M over a single area of energy generation.

WHERE WE ARE TODAY

The Ecogrid board members are currently working on a variety of issues. Currently, Ecogrid is a pass through non-profit organization. Patent and trademark applications have been filed and are pending. Funding options are being fully explored.

Once initial funding is in place, a broad and comprehensive feasibility study is planned. Only then can decisions be made as to the exact initial shape and extent the Ecogrid will take and what services will be included and when.

Because the planning of the project is the most important step, the object is to make the Ecogrid easily expandable to include ever more of the community; easily adaptable, to allow for whatever changes might occur, easily maintainable, because if a system cannot be maintained, it will not be maintained and therefore cannot be efficient and effective, which are two more characteristics required of the Ecogrid systems. Expansion will be a good problem to have, as a successful Ecogrid will pull in more and more people who want to live a better life style. A doubling or tripling of the community is a likely scenario with a successful sustainability program.

Discussions are underway to study the feasibility of rather than putting these loops directly in the ground, instead, putting them in accessible service tunnels that run the length of the town, similar to a sewer tunnel but containing all the piping, electrical and communications lines. This would allow for ease of maintenance and ease of expandability of services the Ecogrid could provide.

It would seem a good fit for the initial Ecogrid to utilize the excess capacity of the hospital boiler and chiller plant and the prison boiler plant.

THE FUTURE

Initial plans for the Ecogrid will cover approximately one mile by 4 blocks wide of the main town area of Hudson. It will provide heating, cooling and hot water loops and an electrical power loop only. These services should eventually include communications, waste removal, etc.

Ecogrid is intended to serve as an educational tool and a system that can be used as a model for other communities. The planning and execution must therefore be transparent and it must be easily understood and reproduced.

The Ecogrid is also planning to include the community's large low-income housing development so that these households will be able to meet their utility bills in the future. Other options being considered include selling substantial amounts of energy back to the utility company when the grid is in full operation.

CONCLUSION

Today's so-called energy efficient air conditioning and heating systems are very, very different to what is needed for true sustainable systems. Using The Natural Step framework to develop a community energy grid, or Ecogrid, will require developing energy systems that minimize energy use; use only renewable energy sources, and use minimal material resources (which means that the systems must have life cycles at least three times longer than current systems that have

a 20 year cycle).

Very different concepts in comfort and air conditioning must be understood to allow sustainable development in a cold and humid climate. Humidity control in the Summer is a priority rather than cooling control. If we can keep the humidity low in a building, we can use radiant cooling and allow the air temperature to rise and occupants will remain comfortable. If we can keep the radiant temperature down in the summer, we can allow the air temperature to rise and occupants will remain comfortable. The opposite strategy can be applied in the Winter; having radiant warming and adding humidity will allow a lower air temperature to feel comfortable.

With energy costs trending ever higher and maintenance being deferred at an ever increasing rate, communities must take control and ownership of their energy systems interest. They must create systems that will allow for minimization of dependence on fossil fuels and allow for tremendous amounts of flexibility and adaptability. The surest way the community of Hudson is discovering to achieve their long term energy goals was through what is now termed an Ecogrid.