MEMO

Job	**City of St. Paul – Ford site redevelopment – zoning framework district energy study**
Customer	**City of Saint Paul**
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Reuse of existing tunnels and steam plant buildings

Date 11-05-2014

1. Introduction

Ramboll Energy (RE) and Krifcon have been hired by the City of St Paul (the City) as engineering consultants to study the potential for creating an integrated, district energy system for the Ford site redevelopment.

It is the project's aim to deliver a concept that will focus around local conditions, available technologies and anticipated development that is economically viable. The team was asked to evaluate the potential reuse of the existing steam plant building (steam plant) and steam tunnel to the main site.

The project will focus around establishing a distribution of heat through a piping network to a number of buildings, normally referred to as district heating. A district heating network can be scaled to supply heat to an urban development area, a university campus, or to an entire town or city.

District heating in the United States has traditionally been based on steam distribution, where the vast majority of European district heating systems today are based on hot water. Steam or medium/high temperature hot water networks were more frequent in Europe in the early days of district heating, but hot water systems have been the preferred option for 50 years or more. All new networks are based on hot water with a maximum temperature of 230°F (110°C).

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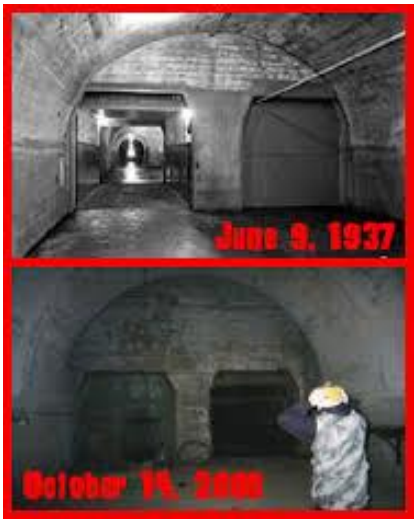
2. Ford Site - steam concrete tunnel, vehicle tunnel and sand tunnels

The Ford site has an old steam pipe that runs through a bridge structure from the steam plant building to the bluff face and then runs through a tunnel about fifteen feet below the surface to the center of the former assembly site.

Further below the surface, at a depth of about eighty feet, is an old vehicle tunnel used until around 1959 for getting cars from the assembly plant to the river. In addition, there is an extensive network of sand mining tunnels, created from 1926 to 1959, when the plant produced glass for vehicle windows with silica mined from underground sandstone on site. When Ford stopped making glass on site, the mining tunnels were shut down and the entries closed, but the tunnels remain.



Picture courtesy of Action Squad website www.actionsquad.org/ford

The lengths of the tunnels vary:
- the vehicle tunnels are around 750 feet each
- the mined sand tunnels are in total around 12,500 feet
- the utility tunnels (steam, sewer and electricity) are around 4,000 feet

Ford Motor Company hired geo-technical consultants to evaluate the tunnels in 2008. The analysis concluded that the tunnels were stable, but additional analysis will be required if any of the tunnels are contemplated for reuse.

With entirely new infrastructure planned for the redeveloped site, including a potential new hot water district heating network, Re finds it difficult to justify the reuse of the existing tunnels on the main site for district energy pipes.

From a planning perspective it would give some unnecessary – and costly – restrictions on the pipe routing for the district energy network. The reuse of the tunnels combined with pre-insulated pipes would be a technical challenge during design and installation, and the overall costs of the network are therefore likely to be significantly higher than they would be otherwise.

However, if the former steam plant is repurposed for a new energy use, then the old steam pipe bridge and tunnel would be useful in getting the new pipes from the plant, under Mississippi River Boulevard to the site boundary. It should be noted that once all equipment is cleared from the tunnel, a thorough condition and structural report should be conducted of the steam tunnel structure and bridge.

Pictures courtesy of Ramboll taken during site visit

The other tunnels may be able to be used as a storm water basin, or more easily for cultural/communal activities. As an example it can be mentioned that in Copenhagen an old underground water reservoir is today used as a museum.

Pictures courtesy of the museum "Cisternerne" website www.cisternerne.dk/en/

2.1 Overall steam versus hot water piping

The piping technology used for the distribution networks was more or less the same for steam, medium/high temperature hot water, and hot water systems until the 1970s. Pipes were installed in concrete ducts and were either insulated individually with mineral wool (or a similar material), or the concrete ducts were filled with an insulating compound, often bituminous, after installation of the pipes.

The introduction of pre-insulated pipes in the 1970's was an important step towards cheaper hot water networks. The industry experienced some difficulties with the new technology in the early years but during the 1980's most of the initial problems was solved. Since then, pre-insulated piping systems have been considered the only option when hot water district heating networks are planned and designed. The practical temperature limit for these systems is 250 ^{o}F (121 ^{o}C), since an elevated temperature will damage the insulation and shorten the service life of the pipes considerably.

Concrete ducts are still used for steam and medium/high temperature systems and some operators in Denmark still insist on using them even in lower temperature hot water networks. In particular, when they relocate large dimension pipes in an urban environment with a high density of other services, they see an advantage in the flexibility offered by concrete ducts. Another point to consider is the demand for maintenance - pre-insulated pipes may require excavation (e.g. to replace casing joints), but pipes in modern, high-

quality concrete ducts can be left in the ground for 50- 100 years. This could be attractive under certain circumstances to some network operators, despite the higher costs.

Modern pre-insulated piping systems rely on the interaction between the pipes and the surrounding soil to keep stresses and pipe displacements at an acceptable level. When an older network of pipes in concrete ducts is about to be replaced with pre-insulated pipes, it is sometimes suggested to run the new pipes in the old ducts, but this is normally inconsistent with fulfilment of the pipe/soil interaction requirements.

Any issues that may accrue due to increased frost debts will need to be considered during a concept design phase.

3. Existing Steam Plant Buildings

Reuse the former steam plant buildings should be considered when the new energy system is established.

RE has some experience with the reuse of buildings for energy systems and, in general, it cannot be recommended. The technical difficulties encountered when combining new installations with an old building structure are often underestimated and the costs are high. The reuse of buildings should therefore – in RE's view – be generally avoided, unless architecture, planning, or other specific conditions justify it. In this case, RE recognizes that there are other interests in building reuse that go beyond technical considerations.

Architect Albert Kahn designed the main steam plant building, along with hydro plant building and main assembly building at the Saint Paul site. Albert Kahn, the foremost American industrial architect of his day, designed a number of landmark buildings in the United States and for Ford Motor Company. He was sometimes called "the architect of Detroit". Together with his brother, he developed a new style of construction where reinforced concrete replaced wood in factory walls, roofs, and supports. It was this that interested Henry Ford.

Another motivation for retention and reuse of the existing steam plant is the assumed difficulty of getting approvals to construct a new energy production plant next to the Mississippi River.

In this context, reuse of the steam plant buildings should be considered. Once the buildings are cleared of the former equipment, which RE does not suggest to reuse, the buildings condition and structural integrity should be carefully assessed. It is not certain if the existing chimney can be reused, since the environmental and permitting requirements will have changed from when it was originally established.

Picture courtesy of Ramboll taken during site visit

It should be noted that the existing steam plant buildings has far more space than would be needed for a new energy production plant. This opens up part of the buildings to be used for other purposes. The rooms on the upper floor, one of which is shown on the picture above, could be used for an innovation visitors' center, a renewable energy teaching facility, maybe with a café and restaurant available to the public.

4. Summary

In summary, we can highlight the following for consideration by Ford and the City of Saint Paul:

- Depending on its condition, it can be an advantage to the future district energy infrastructure for the site to reuse the portion of the steam tunnel that connects the steam plant building to the boundary of the main Ford property.
- The sand tunnels do not provide a good conduit for new energy infrastructure to and on the main redevelopment site. They may be considered for reuse for other purposes.
- Depending on its condition, the steam plant buildings can be an advantage to use as a new energy center, with remaining space in the buildings available for other uses, such as a teaching facility and/or a restaurant.

5. References

http://en.wikipedia.org/wiki/Twin_Cities_Assembly_Plant
http://www.actionsquad.org/ford.htm
http://en.wikipedia.org/wiki/Albert_Kahn_(architect)