DISTRICT ENERGY DIGEST

No. 8, June 2024

DISTRICT ENERGY DIGESTS are produced every four months by the **Boltzmann Institute**, **described here on Page 6.** They provide brief accounts of recent items relevant to the deployment of district energy, many with a focus on the Greater Toronto and Hamilton Area (GTHA). This issue (No. 8) is unusual because it reports highlights of the Boltzmann Institute's study tour of 12 northern European district energy systems during May and June 2024 (see Page 3). As before, an annex is dedicated to the Boltzmann Institute's main ongoing project (see Pages 7-8). Back issues of the *Digest* are at link. To subscribe, please write to link.

Items concerning the GTHA, Ontario and Canada

Canada's Thermal Corridor is the name given to a proposed heat network in Hamilton that would capture residual heat from industry and deliver warmth and domestic hot water to some 7.5 million square metres (m^2) of building space in the lower city and beyond. The concept is for an energy utility of national significance that would attract new companies to Hamilton, including those that use or produce large amounts of heat. It would provide an alternative to electrifying building heating in Ontario – "a massive undertaking sure to drive up energy costs" (link).

Hamilton Community Enterprises (HCE), owned by the City of Hamilton, leads this project. A report on the fourth phase of the preparatory work is due this summer. Known as HCE's Energy Harvesting Study, the one-year phase "is being conducted in partnership with industry (heat producers) and building constructors, owners, and operators (heat users), and is intent on identifying a commercial model and governance structure that would ensure the long-term sustainability of a low-carbon thermal distribution system" (link). HCE already operates a small heat network in the downtown.

Harvest Systems Inc is a related Hamilton company focusing on heat recovery from the restaurant business (link). With a June 2024 order of 20 units from Pizza Pizza for its POWER system (Pizza Oven Waste Energy Recovery), the company is moving from innovation to commercialization, all in collaboration with McMaster University.

Zibi, a mixed-use development in Ottawa, is to use otherwise wasted heat from the Kruger Products paper plant across the Ottawa River in Gatineau, Quebec. Modelled on Danish practice, the system is claimed to be the first in North America to use post-industrial waste recovery in a master-planned community. Eventually, the Kruger plant will heat residential and industrial floor space totalling nearly 400,000 m^2 on both sides of the river. Zibi – meaning *river* in Algonquin – is on former industrial land considered sacred by the Algonquin people, who have approved the development (link). Although Kruger's heat comes from natural gas, the repurposing of what would be wasted heat will increase efficiency and reduce potential use of electricity or further natural gas for space heating.

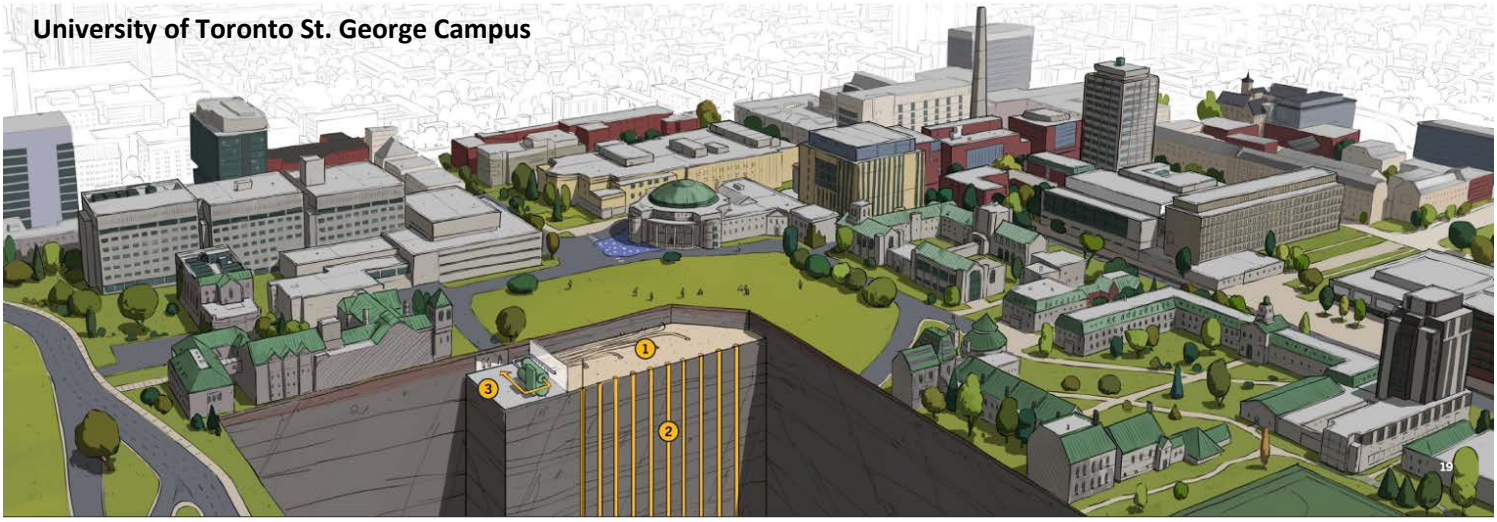
Hydro Ottawa facing historic capital investment. This was the headline of a news item (link) concerning the June 25 presentation of the company's 112-page, 2023 annual report (link) to Ottawa City Council. This may be the first time one of Ontario's local electricity distribution companies (LDCs) has publicly acknowledged the scale of the investment challenges posed by proposed widespread

electrification, particularly of space heating. Hydro Ottawa is venturing gently into heat network development. Its annual report notes partnership in two Ottawa projects, including the one noted above. We hope to meet soon with CEO Bryce Conrad to show how heat networks can help reduce required investment by LDCs.

District Energy In Canada. This is the title of a December 2023 report (link) produced for Natural Resources Canada by the Canada Energy and Emissions Data Centre at Simon Fraser University in Burnaby, B.C. (link). The report is based on one of three downloadable databases, the one for Innovative Energy Facilities, which "combines information on district energy, cogeneration, renewable electricity, and biofuel production" (link). Some of the hosts for our recent study tour (see below), asked us to introduce ourselves with a brief presentation. Our short slide show (link) was based in part on this database. We noted that across Canada there are some 240 district energy systems (65 in Ontario and 20 in the GTHA). The large majority of these serve institutions: education, governments, prisons, airports, etc. Very few are of the kind we studied in Europe – businesses with paying customers. These include six in the GTHA run by three companies.

University of Toronto's district energy system. This was one of two systems highlighted in our presentations in Europe, the other being Enwave's Deep Lake Water Cooling System (link). The university's system serving its downtown campus dates from 1912 and is undergoing both a doubling of floor space served from today's one million m^2 and evolution to an electric-heat-pump-based heating and cooling system supported by borehole storage, an unquestionable improvement over the present natural-gas-fuelled heating system. (See link, also for the illustration below.) The system will use electricity, but less than air-source heat pumps serving an equivalent load, both annually and at the system peak, resulting in lower emissions from natural-gas-based generation, reduced need for system capacity, and lower running costs. The last will be important in view of the likely substantial rise in electricity rates – as suggested above – due to system expansion driven by electrification.

University of Toronto St. George Campus



1. Over 370 boreholes have been drilled 250 metres deep.
2. Water is circulated through a U-shaped pipe in each borehole, taking excess heat from buildings in summer and storing it underground for use in winter.
3. Heat pumps circulate the water around the campus, transferring heat to and from building ventilation systems. An underground display serves as an applied learning classroom.

Study tour highlights

Overview. There were seven participants in the Boltzmann Institute's study tour of 12 district energy facilities in northern Europe, in May and June 2024 (see the photo and caption on Page 4). In advance, we sent our hosts ten questions as a basis for discussion together with four to six questions specific to each system (link).

Two strong conclusions from our dozens of discussions with people at the forefront of moving Europe towards carbon neutrality are these:

1. There's optimism that decarbonization by 2050 of space heating and cooling is fully achievable and affordable, *if* heat networks are implemented in most urbanized places. (We noted pessimism as to whether decarbonization of transport and other sectors is achievable by 2050 or even later.)
2. The most important step towards decarbonization of space heating and cooling in an urban area is development of a heat plan: identifying on a neighbourhood basis what the thermal demands will be in the years until 2050 and how they will be met.

As an early outcome of the study tour, we'll be planning a Fall 2024 event designed to address the question: **Should Ontario municipalities be required to engage in heat planning?**

Our further conclusions are to be set out in a report on the study tour we plan to post at our website during August 2024 (link). In the meantime, what follows are highlights of each of the 12 systems we studied.

Leeds, UK (May 21): We met with representatives of the City of Leeds and Vital Energi (link), the company that operates the Leeds heat network, and visited the Recycling and Energy Recovery Facility (link, link). Usually in Europe, incineration of waste that cannot be recycled is seen as more environmentally sound than landfilling it, especially if, as in Leeds, the plant provides heat and electricity generation – combined heat and power (CHP).

Leeds City Council has been forthright in its support for district heating as an element of its plan to achieve carbon neutrality in its operations by 2030. National legislation requiring connection to heat networks is expected in 2025. Leeds is part of a pilot scheme for this and is already authorized to require connection of most new development where a heat network is available (link).

Amsterdam, The Netherlands (May 24): Amsterdam's predicament may be among the closest to that of the GTHA and most Canadian urban areas – in that space heating is now predominantly by natural gas and will have to change dramatically to become decarbonized by 2050. Amsterdam already has a significant amount of district heating – serving perhaps 15% of its floor area – and, importantly, has an impressive, well-argued municipal plan for near-complete decarbonization of space heating by 2040 (link) – since put back to 2050.

We met with officials of the City of Amsterdam and of Westpoort Warmte (WPW, link), the district heating company, 50% owned by the City, that serves the north and west of Amsterdam mostly with heat from a CHP waste incinerator. WPW plans to grow threefold by 2040. As well as current sources, heat could be added from data centres, solar and geothermal sources, and hydrogen combustion.

The delay in decarbonization may reflect changing politics in Europe following reduced representation by Green parties (link). A new Netherlands' government has policies with uncertain impact on the development of heat networks. It will add nuclear plants, seek offshore natural gas, and rescind the heat-pump mandate (link).

Kristiansand, Norway (May 27): Our host there was Å Energi (link), whose main business is hydroelectric generation and distribution of electricity in south Norway and to the European grid. Å Energi also provides heat networks. Heat sources include waste incineration, bioenergy, and wasted heat from industrial plants.

Where heat networks are established in Norway, there is a requirement to connect but not to use. Thus, there is competition from heat pumps that use (relatively) low-priced electricity. Within Å Energi, marketing of

electricity and heat are kept strictly separate, but the two parts of the business compete for capital. Å Energi (but not always government) understands that the electricity and heat businesses can be complementary: well-functioning heat networks can help with electrical grid management. Heat-network piping is installed to a 100-year standard, but investments are capitalized over 25-40 years, still an unusually long period for investors.

Aarhus, Denmark (May 28): Copenhagen is said to be the world leader in district energy, but we gained the impression that Denmark's second city, Aarhus (population 360,000), may often have been leading Copenhagen. Our host was Kredsløb AVS (link), the municipally owned company that provides heating to 95% of the floor space in Aarhus – 24 million square metres (m^2) – with connections to about 65,000 buildings.

After presentations and discussion, we visited the Lisbjerg Energipark, where a CHP plant produced half of the annual 3 TWh of heat for the heat network from wood pellets and 20% each from straw burning and from incineration of the one-third of municipal waste that can't be recycled. Kredsløb claims to have provided entirely carbon-neutral district heating since 2017, achieved by counting waste incineration as part of decarbonization, a position that is mostly accepted in Denmark and the rest of Europe, but not entirely (e.g., link). More controversial is the current dependence on wood pellets, mostly imported, which Kredsløb will soon replace. Deep geothermal energy – Aarhus is an acknowledged European leader (link) – will provide 20% of delivered heat, with the remainder to come from boilers and heat pumps using low-cost electricity.

Rostock, Germany (May 29): Our hosts in the former East Germany's largest port were the City of Rostock and Theta Concepts GmbH (link), a consultancy specializing in the municipal heat transition. After intensive discussion, we visited the main CHP plant of Stadtwerke Rostock AG, the mostly City-owned company that operates the district heating network (link). The heat network connects 60% of Rostock's buildings, including many single-family dwellings (SFDs) but mostly City-owned or coop-managed apartments, providing about 45% of the city's space heating load. This market penetration is high for Germany, but typical of the former East Germany. The goal is to reach 80% penetration. The fuels for the two CHP plants are natural gas (75%) and coal (25%), with the intention of moving away from fossil fuels by 2045.

The study group and hosts in front of Rostock City Hall. L to R: Uwe Hempfling (City of Rostock), Richard Gilbert, Stephen Taylor, Raphael Wittenburg (Theta Concepts); Peter-Paul Bloemen, Dorian Holtz (Theta Concepts), Barry Green, Caleb Duffield, John Stephenson, Nayel Halim.

German municipalities must have heat plans in place by 2028, for which the federal government is providing funding. Rostock completed a heat plan in 2022 and is working on implementation. Potential non-carbon heat sources include heat-pump-augmented sewage heat; excess electricity from wind farms; industrial waste heat including heat from electrolysers; deep geothermal sources; and incineration of biomass, municipal waste and sewage sludge. Also contemplated are up to five pit storage facilities, holding up to 33 GWh as hot water.

Tallin, Estonia (May 31): After a complex post-Soviet phase of privatization, Tallin's widespread heat network is now owned two-thirds by our host AS Utilitas and one third by the City (link). Tallinn's system is in transition from natural gas fuelling, with a 2035 target of using only renewable energy (link). Tallinn's decarbonization efforts received a boost when it was designated Europe's Green Capital for 2023 (link).

Tallinn's heat network extends for about 520 km, serving 70% of floor space (about 18 million m^2), to be 80% by 2032 – the remaining unserved space mostly in SFDs. Leaky piping – dating from the Soviet era – has been a big issue. The aim is to replace the grid by 2034, of which about 70% has been completed. Buildings mostly use Utilitas-approved heat exchangers, separating internal use from local heat networks.

Helsinki, Finland (June 1): Our host was the district heating lead for the Finnish government's research centre VTT (link). The near-complete dependence of Finland's district heating on fossil fuels was down to about 30% in 2023. The interconnected heat networks of Helsinki (1.35 million population), and nearby Espoo (320,000) and Vantaa (250,000) total almost 3,000 km of piping providing an annual 10.5 TWh of heating and 0.3 TWh of cooling. The Espoo system's dramatic shift away from 100% reliance on fossil fuels in 2014 to 40% in 2023 is to be further enhanced by the proposed largest-ever use of data-centre heat – from a massive Microsoft facility. Vantaa's rapid decarbonization has been chiefly based on waste incineration. Helsinki's district heating system still uses coal as its main fuel, and may look to use of nuclear energy (link, link).

Of special note is Varanto, the world's largest cavern thermal energy storage (link), soon to begin construction in Vantaa – to store up to 90 GWh across seasons as 1.1 million cubic metres of pressurized hot water at up to 140°C in three lined caverns hewn out of bedrock 60 metres and more below ground. The estimated cost is about US$215 million or about US$2.20/kWh. (See Issue No. 7 of this *Digest* for comparative costs per kWh.)

Stockholm, Sweden (June 2): Our host was the Stockholm manager of FVB, a Swedish consultancy also active in North America (link). He overviewed energy trends in Sweden and nearby, noting recent high energy prices, particularly for biofuels. The EU considers Swedish use of forest fuels to be not renewable. There's talk of building new nuclear plants and firmer plans to use heat from large data centres.

Sweden's district energy is less regulated than in other European countries. District heating companies say it allows flexibility and precise adjustment to local conditions. Recent price increases have led to calls for price regulation, adding to concerns about a privatization trend that has also been associated with price increases.

Visby, Gotland, Sweden (June 3): Gotland is a mostly agricultural island in the Baltic Sea about 60 km from the Swedish mainland with a resident population of just over 60,000. Our host was Gotlands Energi AB (link), owned 25% by the municipality and 75% by the Swedish government. The heat network has been fossil-fuel-free since 2006. It depends on local forest bio-energy and bio-oil, on augmented heat from seawater and sewage, and on bio-gas from a closed landfill. Many SFDs are served as well as larger buildings including an apartment building more than 500 years old.

Gotland had been designated by the Swedish Energy Agency as a pilot for work towards sustainable systems, but the project Energipilot Gotland ended in 2024 (link). A 2024 initiative involving Bornholm (see below), Gotland, and Åland (a Finnish archipelago where Swedish is the main language) has the goal of producing hydrogen from offshore wind power and its delivery by pipeline (the Baltic Sea Hydrogen Collector, link).

Rønne, Bornholm, Denmark (June 4): Bornholm is a smaller Baltic Sea island, some 35 km from Sweden's south coast and 130 km from any other part of Denmark. Our hosts were Bornholms Energi & Forsyning (link) and Baltic Energy Island, a Bornholm-based partnership and foundation aiming to transform the island "into the green hub in the Baltic Sea" – including the hydrogen production and distribution noted above (link).

We visited a fully automated CHP plant being fuelled by 500-kg straw bales. The one employee associated with this plant also provided maintenance for other automated plants on the island. In the plant we visited, wood chips from local sources are the other main fuel, with rare oil use as a back-up. Wind turbines are the main source of electricity (44% of energy supplied).

Kiel, Germany (June 5): Our host in Kiel was Stadtwerke Kiel AG (SWK, link), owned 49% by the City of Kiel and 51% by the MVV Group, which in turn is majority owned by the City of Mannheim. SWK provides electricity, natural gas, heat, and water services to Kiel – population about 250,000 – and some surrounding communities (serving about 100 km^2 in all). The heat network extends for almost 400 km, serving what may be about 40% of the served area's floor space and providing SWK with 24% of its sales revenue

SWK and its predecessors have provided district heating since the 1960s. It was primarily coal-fuelled and distributed steam until 2018, when the heat network became hot-water-based at about the time of commissioning of Kiel's Coastal Power Plant (Küstenkraftwerk Kiel). This plant provides electrical and thermal energy (each about 190 MW) from 20 highly efficient (>90%) natural-gas-fired Otto cycle engines, linked to surface storage of 42,000 m^3 of hot water, enough to serve the 78,000 connected buildings for 8 hours.

Further decarbonization is required to meet Germany's 2045 goal for net-zero emissions (and to move to negative emissions by 2050). The main element of SWK's plan for this is conversion to hydrogen fuelling, chiefly sourced from electrolysers powered by Baltic Sea wind farms (see above on Gotland and Bornholm). Geothermal energy is also being explored: water at up to 76°C pumped up from 2-3 km below ground (link).

Copenhagen, Denmark (June 6): Our host was a senior engineer with Rambøll Group A/S, a Danish architecture, engineering and consulting company with offices in 35 countries and some 18,000 employees. A Rambøll goal is to be a leader in green energy with some emphasis on heat networks. Our host developed what may have been the first municipal heat plan – for Aarhus in 1980 – and since then has been involved in heat planning in Greater Copenhagen as well as in 25 other countries.

All district heating in Denmark operates on a non-profit mode. Cooling can be market-based. Both are mostly financed by low-interest municipal bonds. Actual management of systems is usually by municipally owned companies or consumer cooperatives (a total of 25 of both kinds in the Copenhagen region). Copenhagen's system is said to be the world's largest, delivering near-carbon-neutral heat to some 75 million m^2 of floor area. Its backbone is a 160-km transmission system providing 110°C water (at 2.5 MPa). It connects with 20 distribution systems serving customers in 22 municipalities, supplying about 8.5 TWh/y.

District heating has become somewhat controversial in Denmark, the result of Green Party preferences for heat pumps over heat networks – because the latter may not be moving away from fossil fuels quickly enough – all supported by an energetic heat-pump industry. Denmark's very high market penetration of heat networks (99% in Copenhagen; 67% nationwide) means that more extensive use of electrified heating is not as much of a problem as it would be in Canada, but it is still a matter for concern among grid managers.

About the Boltzmann Institute

We're a federally incorporated, not-for-profit organization founded in 2022, seeking to help eliminate harmful emissions from human energy use, named for Ludwig Boltzmann, a 19th-century Austrian founder of the science of thermodynamics.

We aim to contribute research and education towards securing carbon neutrality by 2050, initially focusing on thermal energy use in buildings (heating and cooling).

Our website at www.bi-ib.ca is a growing resource – now partially bilingual – on district energy and related matters including electricity generation.

Our early funding came from generous private contributions. The Government of Canada is now contributing $750,000 to the work of the Boltzmann Institute described in the annex to this *Digest* on the next two pages.

WHAT WE'LL SEE DOWN TWO PATHWAYS

This is a regular two-page annex on the Boltzmann Institute's Two Pathways project, which is considering the pros and cons of two pathways to zero direct emissions from buildings: one where heat pumps predominate and the other when most buildings are served by district energy systems (heat networks). It contains reflections by the project manager, John Stephenson, on returning from the study tour of northern European district energy systems highlighted on previous pages.

Greenhouse emissions from buildings exceed any other sector in the GTHA. The trend of several years shows no improvement (according to The Atmospheric Fund, at link), despite all the attention, e.g., with taxpayer funded subsidies for heat pumps. Yet buildings should be the easiest sector to reduce because most of the energy needed for building operation (chiefly for space heating) is low-grade – at relatively low temperatures – available from renewable or otherwise wasted or unused sources.

There are many examples of how to do it, all involving thermal networks, like the recent University of Toronto seasonal thermal energy storage project storing waste heat to use in winter, thereby decreasing gas burn in their boiler plant, reducing emissions from the St. George campus by an estimated 15,000 tonnes per year. (See further information about this, and a diagram, here on Page 2.) We learned on our study tour that Stockholm's district heating system has grown over the last 20 years to serve 73 million square metres of floor space while reducing emissions intensity from 20 to 3 kilograms of carbon dioxide equivalent/square metre. That's for existing buildings. It is as low as the strictest Toronto Green Standard proposed for new buildings.

Evidently, thermal energy networks are a proven formula for success. The technology does not receive recognition or support from senior levels of government, or the real estate community, commensurate with its potential for helping to meet emission reduction goals at an affordable cost. The Two Pathways project is one way Boltzmann Institute and its partners, McMaster University Institute of Energy Studies and FVB Energy Inc, aim to change those outdated attitudes. We will lay bare the comparative societal and ratepayer costs of heating decarbonization down a pathway that includes extensive development of thermal energy networks versus the current pathway, where it is largely restricted to new development, or to institutions such as the University of Toronto.

In a fossil fuel free world, consumer costs will be driven almost entirely by capital to build and maintain infrastructure, whose magnitude, in turn, is dictated by peak demand. Now, there's the rub. It's a truism that you can't manage what you don't measure, and peak heat demand is hardly ever measured except by a few district heating companies. Some consultants rely on models, which are totally unreliable in my experience. (Garbage in, garbage out.)

Peak heat demand is key to understanding the relative costs of decarbonizing heating by various strategies. With the help of mechanical engineering graduate students at McMaster, this research project will shed light on the estimated peak demand in the service areas of local electricity distribution companies in Ontario. Other students will be gathering data on local sources of heat and

how they can be leveraged with thermal energy storage (TES). TES is rarely used on a utility scale for heat in North America, yet it was conspicuously ubiquitous on the study tour. That should tell us something.

Meanwhile, FVB Energy Inc is currently developing showcase costs of the main components of thermal energy systems (energy centres, distribution piping and customer connections) as applied to different situations, e.g., downtown existing buildings, old suburbs, new suburbs etc., as well as the direct costs to the customers down each pathway. This will be the best and latest cost information available using the methodologies that have under-pinned business cases for many thermal energy networks that have been approved for financing in Canada.

Seasoned business professionals at the Boltzmann institute will put all the above information together with relevant information that has been published by others. The aim is to clearly and fully represent the true cost to consumers, and to the larger community, of decarbonization down each pathway. This intelligence is currently largely absent; the danger being that Canada could be heading to a Tragedy of the Commons outcome, wherein individuals pursuing their own best interests won't necessarily result in the best interest of the overall community.

Much of this information is scheduled to be gathered by the end of 2024 and a final report will be presented to the Net Zero Advisory Body and others before the end of the first quarter of next year.

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This project is supported by a contribution from federal government agencies (see the logos below) awarded to the Boltzmann Institute after a competition among universities and think tanks. The project is to be completed by March 31, 2025. We'll be disseminating results as we get them through future editions of this *Digest* and other means. Please e-mail the project manager John Stephenson (link) with questions, comments or in-kind contributions to the project.

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Net-Zero Advisory Body
Groupe consultatif pour la carboneutralité