DISTRICT ENERGY DIGEST

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DISTRICT ENERGY DIGESTS are produced every four months by the Boltzmann Institute.

This issue's contents:

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The Boltzmann Institute's March 20 conference on municipal heating planning

This all-day event at the University of Toronto's Faculty Club will address the question, "Should Ontario municipalities be required to engage in heating planning?" A near-final program is distributed with this issue of the *Digest*. The program is available at link, with a two-page document that answers ten questions about municipal heating planning. To register, go to EventBrite's website at link – where there's also a copy of the program. Questions or comments about the event should go to link.

News from the Toronto Region and elsewhere

October 21 saw the groundbreaking celebration for a major new district energy system at Lakeview Village (link, link), a 72-hectare development on the site of the former coal-burning Lakeview Generating Station, on the Mississauga side of the boundary with the City of Toronto at Lake Ontario. There'll be 16,000 residential units and 140,000 square metres of employment space. The latter is to be the Lakeview Innovation District – "an environment where people can research and develop innovative solutions that help to educate and drive behavioural change globally" (link).

The system will heat and cool buildings through a thermal network of hot and cold water pipes. It's anticipated to cost $35 million (link) and will be built and operated by Enwave Energy Corp (link) in part using heat extracted from wastewater at a new sewage pumping station to be operated by the Region of Peel or the City of Mississauga. The station will house the district energy operations centre and an "educational space to provide learning opportunities for Mississauga residents, visitors and the business community." It's not clear whether supplementary heat will be needed for extreme cold weather – which could also be handled through use of hot water storage if made available.

The Lakeview system was highlighted at a sold-out event hosted by Peel Region on November 5, "Unlocking Ontario's Low-Carbon Future with District Energy," organized by the Centre for Community Energy Transformation (link, link) and the Royal Danish Consulate General in Toronto. The event focused on district energy systems for new developments – to form about 30% of Ontario's building stock in 2050. What may be needed is an event of equal excellence that addresses the trickier question as to how to introduce district energy to much of the 2050s' building stock that is in place today.

District energy is proposed for the massive Downsview Airport redevelopment: This federally owned, 210-hectare "city within a city" will have 63,000 residential units (average occupancy 1.8 in buildings from six to 60 storeys) and space for some 52,000 jobs (commercial-institutional and light industry). An article by Ian Harvey at link highlights the developers' ambitions to avoid use of fossil fuels, notably by considering geothermal facilities, even including wells drilled as deep as seven kilometres.

A key part of Harvey's discussion concerns timing in relation to the City of Toronto's ambition to achieve community-wide, net-zero greenhouse gas emissions by 2040. He quotes Jeff Ranson, director of responsible development at Northcrest, Downsview's main developer, "We don't know what the performance standards will look like in 2040. We don't know what the regulatory mechanisms will look like. We don't know if there will be a fine for non-compliance. (Northcrest [link] is a subsidiary of the pension manager for the armed forces, RCMP, and other federal employees [link].)

Canada Lands Company's rendering of the proposed streetscape at Downsview's West District (from link)

The very first item in these *Digests*, in the February 2022 issue (link), concerned progress with district energy in Edmonton. Highlighted was the system for the Blatchford community, now in its sixth year, located on the site of the former city airport with plans to serve up to 30,000 residents. In July 2024, the federal government announced $23.7 million for expansion of the system, with $55.5 million to be provided by the system's owners, the City of Edmonton (link).

What is known as the Blatchford District Energy Sharing System "uses a geoexchange field which harnesses the shallow geothermal energy below the Earth's surface … [it] consists of 570 boreholes that are 150 metres deep. It acts like a massive ground energy battery that 'charges' the system" (link). This system is separate from Edmonton's downtown system, noted in the February 2024 issue of this *Digest* (link), now expected to begin operation during 2025.

Expected worldwide developments in district energy during 2025

- Massive expansion of district energy is continuing, especially in Europe (link) and China (link).
- Much implementation of large-scale thermal energy storage systems (link).
- Continued growth in the share of renewable energy in district heating, now at 40%, and in use of otherwise wasted heat from wastewater, industry, data centres, electrolysis, etc. (link).
- The move to lower-temperature heating networks will continue, as they work better with non-fossil heat sources (link).
- There'll be more use of massive heat pumps in district energy systems to achieve desirable temperatures of working fluids (hot or cold water) – in ways that provide much better performance than can be achieved with smaller at-building heat pumps (link).
- Other heat sources set to expand in use include nuclear energy (link) and geothermal energy (link) including deep geothermal (typically >2 km below the Earth's surface; e.g., link, link, link).
- District cooling is also expanding, usually in conjunction with district heating but also alone, as in Southeast Asia (link).

District energy's advantages: 1. Flexibility as to energy sources (data centres?)

There would be three main advantages to the widespread deployment of district heating in Ontario (and much of the rest of urban and suburban Canada):

1. Ability to make use of heat from non-carbon sources and otherwise-wasted heat.
2. Ability to make use of the very low-cost storage of thermal energy.
3. Ability to massively reduce demand for electricity, particularly during winter peak periods.

Flexibility as to energy sources is the most important advantage of district energy. It's the one that allows use of a wide variety of non-carbon heat sources and heat sources that may not otherwise be usable. Much in the news in early 2025 is the rise of artificial intelligence (AI), its dependence on massive, electricity-hungry data centres, and the challenges of keeping the equipment cool (e.g., link). An excellent article by Mark Spurr in the 2025 Q1 issue of the International District Energy Association's magazine *District Energy* has the title "District energy systems are the key to recovering data center waste heat" (link). It begins (slightly edited with sources added):

> On average, a ChatGPT query needs nearly 10 times as much electricity to process as a normal Google search [link]. That difference hints at what is coming. Requirements for data processing have increased an average of 120% annually since 2010 – from 2 to 120 zettabytes [link]. Even with progress in data processing efficiency, data center (DC) growth will result in huge increases in global electricity and water consumption as well as generation of waste heat. Global DC power consumption will increase from 400 to 1060 TWh between 2023 and 2030 [link].

Canada was ranked "as the top country in the world for building energy-efficient data centres" in 2020 (link). However, a quick AI-assisted scan of reports on data-centre development suggested that in the early 2020s rates of growth here have lagged behind those of many other countries. This may change during the latter part of the decade, particularly because of ambitions to make Alberta an AI data-centre hub with the goal of attracting $100 billion in investments (link). Much or all of this investment could be achieved with the proposed Wonder Valley data centre project, planned by its main proponent, Kevin O'Leary – onetime candidate for leader of the Conservative Party of Canada – to become "the world's largest AI data centre industrial park" (link).

Wonder Valley's eventual 7.0 GW power consumption would be met by off-grid natural gas generation, and perhaps by deep geothermal sources. There appear to be no plans (yet) for using some of the huge heat output of about 10.0 GW — including heat from electricity generation — to serve buildings in Greenview, where the complex is to be located, or in neighbouring Grande Prairie, population about 65,000. (The 10.0 GW of heat could be enough for more than two million homes.)

Several district heating systems using data centre waste heat were noted in the last issue of this *Digest* (link), including the system in Markham, Ontario. An interesting case noted is Hamina, Finland, where 80% of the community's heating needs are met by Google's donation of heat from its data centre (link), benefitting both Google and Hamina's district energy system.

DeepSeek: In January 2025, in what was described as "AI's Sputnik-like moment" by Marc Andreessen, advisor to Donald Trump (link), this little-known Chinese company made available two open-source AI models with performance akin to models developed in the U.S.: GPT-4o (Open AI), Gemini 2.0 (Google), Claude 3 (Anthropic), LlaMA 3.2 (Meta), MAI-3 (Microsoft), Grok-2 (xAI), and others. DeepSeek R1 and DeepSeek V3 were claimed to have been produced for a small fraction of the development costs of any of these models, a claim that has been contested (e.g., link, link). They're more certainly marketed to businesses at less than a tenth of prices of the U.S. models (link), although the U.S. prices may now be falling (e.g., link).

Energy use of the DeepSeek models for similar functions may be a small fraction of that used by U.S. models (link), although this has also been contested (link). Whatever the case regarding development costs and energy use, the stock price of the main chipmaker, Nvidia, quickly fell by 17% (a capitalization loss of US$560 billion), and continued to be falling into February. DeepSeek's AI assistant soon became the most downloaded free application in the U.S. and elsewhere, including Canada (link).

Regarding energy use, Microsoft CEO Satya Nadella invoked the Jevons paradox – increased efficiency in resource consumption causes more use – to anticipate increased demand in data centres (link). Prospects for synergies with district energy systems may well remain encouraging.

District energy's advantages: 2. Low-cost energy storage

The extraordinarily low cost of thermal storage was illustrated in a table in the February 2024 issue of this *Digest* (link). The table is reproduced on the next page with five additions in italics, all recently in service or under construction at the end of 2024.

The table continues to show very much lower capital costs of thermal than electrical storage (per unit of energy: kWh). When considering the *rate* at which energy can be delivered from storage – i.e., the power in kW – thermal's capital cost advantage is not so large, but still mostly exists. The lowest power cost is that of Sweden's Västerås facility, for which capital costs were relatively low because it is a conversion of a former oil storage cavern complex.

Stored electrical energy has many more uses than stored thermal energy. It's much more valuable *unless* the electrical energy produces thermal energy for space heating, when the two types of energy

Comparison of the capital costs of grid-scale storage of thermal energy and electrical energy

Facility	Capacity (MWh)	Discharge rate (MW)	Cost in 2022US$		Source
			Per kWh	Per kW	
Thermal energy storage (hot water)					
Vojens pit storage	12,180	39	0.56	177.70	link
Høje Taastrup pit storage	3,300	30	3.61	396.70	link
Berlin tank storage	2,600	200	20.27	263.50	link
Varanto cavern storage	*90,000*	*200*	*2.44*	*1,100.00*	*link*
Västerås cavern storage	*13,000*	*500*	*1.26*	*32.71*	*link*
Battery storage (4-hour rating – except Carlton Power and see the text for Edwards & Sanborn**)**					
Moss Landing BESS project	3,000	750	333.00	1,333.00	link
Waratah Super Battery	1,680	850	385.00	762.00	link
Carlton Power	250	250	397.00	397.00	link
NREL for 2023	60	15	446.00	1,785.00	link
NREL for 2050	60	15	220.00	880.00	link
Edwards & Sanborn project	*3,287*	*425*	*270.16*	*2089.41*	*link*
Skyview 2	*1,560*	*390*	*345.00*	*1,380.00*	*link*
Pumped hydro storage (for electricity generation)					
GTM (estimate)			153.00		link
Thunder Said Energy (estimate)	6,000	500	187.50	2,250.00	link
NREL (estimate)				2,737.52	link
Fengning pumped storage		*3,600*		*726.84*	*link*

and their rates of delivery can be compared directly. Heat pumps can reduce the amount of electricity required for space heating by a factor of four (unless it's very cold), but this does not come near off-setting the 150-fold difference in median costs for the listed thermal and electricity storage facilities.

The Västerås cavern storage facility in Sweden could be of special interest because there is a large, partially excavated cavern complex at the Wesleyville site, 100-km east of Toronto, now being explored by the Ontario government as the location of a nuclear generating station (link). The caverns were to store oil to be used for electricity generation at the site, a plan abandoned during the 1970s' oil crisis (link). The eventual storage capacity was to have been 4.8 million barrels (link, link), or about 575,000 cubic metres, several times larger than the Västerås facility. It would have been about half the size of the Varanto facility in Finland, also in the above table – at 1.1 million cubic metres billed as "the world's largest cavern thermal energy storage" (link). Wesleyville's oil storage caverns were to extend for some 5,000 metres, with a cross section of 10 x 16 metres, occupying a 35-hectare square area 70 metres below ground in the 540-hectare site. It appears there could be a massive underground facility there that stores hot water in summer and feeds it to a thermal network in winter.

Two of the other three added facilities are or will be the largest of their type. The Edwards & Sanborn project in California's Mojave Desert includes a huge 1,860-hectare array of 1.9 million solar PV panels. The estimates of battery costs and output were made by excluding what were assumed to be the array's capital costs (US$1 million/MW for an output of 875 MW). The Fengning pumped storage facility, fully operational in December 2024, comprises 12 reversible 300-MW pump-turbine units. It's located about 175 km north of central Beijing. The remaining added facility is the Ontario-based Skyview 2, described in the last *Digest* (link).

The Moss Landing facility – in the original table – is no longer in operation. On January 18, a major fire there — about 125 km south of San Francisco —caused the evacuation of 1,700 neighbours and closure of schools and California's Highway 1 (the scenic route to Los Angeles, about 500 km further south). The massive fire has prompted calls for better regulation of battery facilities (link, link).

District energy's advantages: 3. Huge reduction in peak electricity demand

Electrifying space heating could increase Ontario's peak electricity demand more than threefold (our estimate at link). Such an increase could be impossibly expensive to provide for. Nevertheless, as we've noted in previous editions of this *Digest* (e.g., at link). Widespread electrification of space heating seems to be the currently favoured strategy. Either of the above two advantages of district energy – flexible heat sources and low-cost storage – could contribute to a major reduction in peak electricity demand.

The flexibility of district energy systems means that heat from several sources can be used to raise the temperature of the water delivered to buildings for space heating, simultaneously or sequentially. A system operator can make use of the lowest-cost source at any time or use hot water from available storage. The thermal network allows the use of otherwise wasted energy – e.g., from supermarket chillers, data centres, and even electricity generation itself. Hot water from any of these sources could directly substitute for electric heating, thus reducing the need for generating capacity.

Storage of hot water for space heating greatly expands the availability of heat sources if deliverable through a thermal network. The low cost of hot water storage allows, for example, summer warmth to heat homes in winter and ensure an adequate supply of thermal energy when it's cold outside.

Applied together, with effective planning, these two advantages would reduce by more than half the anticipated increase in Ontario's winter electricity demand, cutting the need for investment in electricity generation by hundreds of billions of dollars. Similar considerations concerning flexibility and storage apply to space cooling using thermal networks delivering cold rather than hot water

The June 2025 issue of this *Digest* will address the one disadvantage of district energy: the cost and disruption involved in establishing the required thermal networks that distribute hot and cold water. Such deployment has been done before in Ontario when the TransCanada natural gas pipeline from Alberta was opened in 1958 and piped natural gas became the predominant heating fuel, replacing coal and oil delivered by trucks (link). It could be done again for deployment of thermal networks.

In June, we'll show that such deployment may be the *only* way of achieving net-zero emissions from Ontario's buildings. Moreover, we'll show that going down the thermal network route will be less costly and more equitable than the alternative of having building owners electrify their heating.

WHAT WE'LL SEE DOWN TWO PATHWAYS

This is a regular 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 where most buildings are served by district energy systems (thermal networks). These annexes are written by John Stephenson, the project's manager, who can be reached at link.

This may be the last update on the Two Pathways study included in the *District Energy Digest*. The final report on Two Pathways will be published in April 2025. The findings will doubtless occupy a good portion of the next *Digest*.

Therefore, it is only right and fitting that this update expresses heartfelt gratitude to the organizations that have collaborated with the Boltzmann Institute on this study. They include McMaster University Institute of Energy studies (MIES), FVB Energy, Inc (FVB) and, in recent months, Market Intelligence and Data Analysis Corporation (MIDAC). The job couldn't have been done without them.

Many "i"s have yet to be dotted and "t"s crossed. Yet stalwart assistance from the above-named collaborators has already enabled accumulation of sufficient quantitative evidence to vindicate the foreboding intuition many of us had about universal electrification of building heating in cold climates using air source heat pumps (ASHPs). Following meticulous analysis of the data, here are some highlights of the results concerning impact on the electricity grid.

- If all the building heat in Ontario currently supplied by natural gas were switched to electricity using ASHP, the electricity system capacity factor — a measure of the extent of the utilization of installed plant – would drop by approximately half.
- The drop in capacity factor would cause electricity rates to more than double in real terms (i.e., on top of inflation).
- The higher electricity rates combined with greater electricity use for ASHPs will triple monthly energy bills for consumers in real terms.
- In these circumstances, continuing the Ontario Electricity Rebate sufficient to maintain stable rates may not be politically feasible.

The Two Pathways report will not be all bad news. It finds that rigorous design and costing of supply of clean district heating to all buildings in an illustrative urban area would cost less than half the capital investment required for expansion of the electricity system to accommodate equivalent new heat load.

Better yet, modest up-front financial assistance from senior levels of government, as is commonplace for such infrastructure projects not only In Canada recently, but world-wide, would enable stable and affordable service fees to households and business.

Better still, Net Zero 2050 for buildings can be reasonably foreseen down the thermal network path-way, whereas that goal is problematic down the electrification pathway. This is because, among other challenges, electrification would require construction of new generating capacity at a much faster rate than has ever been achieved in Ontario's history, along with associated transmission and distribution.

Moreover, thermal networks could even help keep down electricity rates by offering a market for the increased surplus generation concomitant with compliance with the federal *Clean Electricity Regulations*.

The Two Pathways report will elaborate all the above, providing transparent and convincing evidence to support its findings. If in the week following publication of this report a headline in the *Toronto Star* screams "**Electrification to triple household energy bills!**", it will only be the truth finally coming out. About time.

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To support the mandate of Canada's Net-Zero Advisory Body related to research, this project was undertaken with the financial support of the Government of Canada. Funding was provided through the Environmental Damages Funds' Climate Action and Awareness Fund, administered by Environment and Climate Change Canada.

Canada

About the Boltzmann Institute

We're a federally incorporated, not-for-profit think tank 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*.