Energy Systems Integration: A Review and Analysis of District Energy for Ontario

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MUNK SCHOOL OF GLOBAL AFFAIRS
UNIVERSITY OF TORONTO

Executive Summary

Ontario has committed to pursuing opportunities for clean and affordable energy systems. District energy is a community-focused technology that can deliver on these goals by providing efficient heating or cooling services and reducing greenhouse gas emissions. District energy systems connect customers to a range of heating and cooling producers through a thermal network, creating communities that are resilient and sustainable.

Europe has a relatively high number of district energy systems. In particular, Sweden and Denmark have high levels of penetration of district heating countrywide, while cities in Germany, Spain, and Italy have developed highly innovative district energy systems. Best practices can be learned from these success stories. Policies at the municipal and regional level that support district energy have helped enable systems with greater climate and resilience benefits. Additionally, a range of ownership models have driven differentiated systems to market competitiveness. Lastly, diverse innovation projects are developing the new generation of more flexible and sustainable district energy systems.

Across Ontario, district energy systems have been developed by municipalities, universities, and corporations. Ontario does not have a district energy policy comparable to those in place in Denmark and Sweden, but a range of government funding opportunities are in place that can support appropriate district energy projects. While policies that are successful in Europe may not translate effectively into the North American context, there are opportunities to improve the provincial approach to district energy.

Three key gaps in the provincial approach to district energy have been identified in this report. First, the lack of a clear policy for district energy increases project uncertainty and raises barriers to initial investment. Second, the diverse range of stakeholders across government increase the complexity in finding support for district energy initiatives. Third, the focus of funding for energy projects on climate change mitigation projects, rather than adaptation projects, somewhat decrease opportunities for project funding. A more comprehensive and unified approach to district energy at the provincial level could help increase penetration of district energy systems that contribute to Ontario's energy goals.

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Abbreviations

DE - District energy

GHG - Greenhouse gas

ESI - Energy systems integration

DH - District heating

DC - District cooling

DLWC - Deep lake water cooling

CHP - combined heating and power

LTDH - Low-temperature district heating

RE - Renewable Energy

Scope of Study

Ontario's has initiated strong direction in regards to affordable and clean energy systems, alongside commitments to climate change mitigation efforts. The province's *Long-term Energy Plan,* and *Climate Change Action Plan* detail Ontario's commitment to these efforts. The purpose of this study and report is to explore avenues in energy systems integration (ESI) as a means of reaching both climate change mitigation and energy efficiency goals. More specifically, this study focused on district energy (DE) systems within the context of ESI, with the aim to understand if and how district energy could be used in the province in order to reach goals of energy resilience and climate change mitigation efforts. This report will provide an overview of the research, and identify some policy opportunities in regards to district energy development in Ontario.

Background

District energy systems distribute thermal energy to customer buildings through an infrastructure network.[1] These systems can provide heating or cooling services more efficiently and with less greenhouse gas (GHG) emissions than individual home heating by using centralized production or pre-existing temperature gradients.[2] There are also benefits for the end-user, including reduced upfront capital costs for building temperature systems and further savings in space and maintenance costs.[3] A range of ESI opportunities can be enabled by the thermal networks used for district energy, further enhancing system sustainability and resilience.[4] This section provides an overview of district heating and cooling systems and the innovative opportunities they present in improving urban sustainability.

DISTRICT ENERGY SYSTEMS

District heating (DH) has been used globally and in Ontario cities including Toronto, Hamilton, Ottawa, Markham, Windsor, London, Sudbury, and Cornwall. District cooling (DC) has seen less adoption worldwide, but innovative systems are emerging, including the deep lake water cooling (DLWC) system operated by Enwave in Toronto, Ontario. The integration of district heating and district cooling systems together in a thermal network forms a district energy system with the potential for complementary gains in efficiency and sustainability.

A district energy system consists of a thermal network that connects heating or cooling production to customer demand.[5] Both heating and cooling services can be produced by a range of technologies, depending on the local environment and infrastructure; these can be categorized as centralized and

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[1] Harvey, LD Danny. *A handbook on low-energy buildings and district-energy systems: fundamentals, techniques and examples*. Routledge, 2012. Page 600

[2] Ibid, pg. 575

[3] Ibid, pg. 575

[4] Ibid, pg. 575; Lund, Henrik, Sven Werner, Robin Wiltshire, Svend Svendsen, Jan Eric Thorsen, Frede Hvelplund, and Brian Vad Mathiesen. "4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems." *Energy* 68 (2014): 1-11.

[5] Harvey (2012), pg. 561

distributed district energy technologies.[6] Thermal networks, centralized production, and distributed production are described in further detail below.

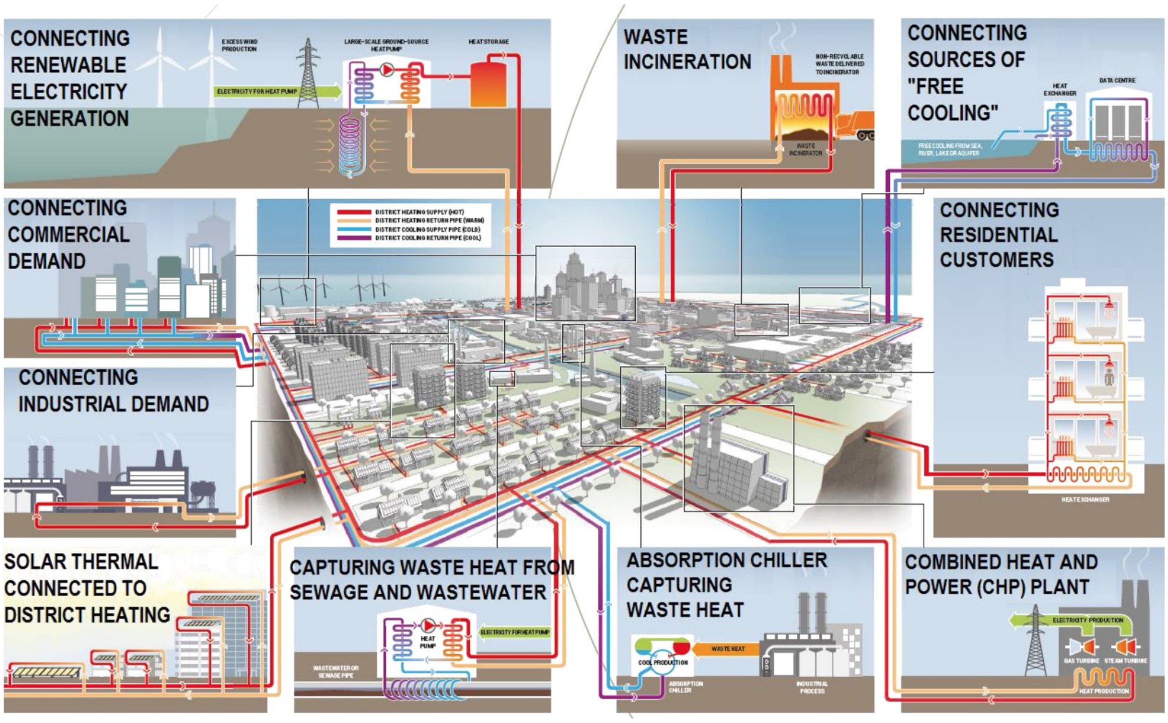

Figure 1: Overview of DE systems and associated production and consumption facilities[7]

THERMAL NETWORKS

A thermal network consists of insulated underground pipes that carry water, steam, or another thermal-transfer fluid that is heated or cooled at production sites. These pipes can economically extend tens of kilometers, although minimizing the distance of transport improves the overall efficiency of the network.[8]

District heating systems typically use either steam or hot water as a transfer fluid.[9] Steam systems are more common in Ontario and have the advantages of not requiring pumps and high thermal energy density, making the technology easier and initially cheaper. Thermal networks using hot water are more efficient and have lower operation and maintenance costs. Low temperature district heating (LTDH) networks using water can allow for low-grade thermal energy sources and solar energy to be used. Consequently, hot water is generally the preferred choice for modern district heating networks.

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6 Ibid, pg. 575-600

7 UNEP. "What Is District Energy? | DISTRICT ENERGY INITIATIVE." Accessed April 11, 2018. Retrieved from: http://www.districtenergyinitiative.org/what-district-energy.

8 Harvey (2012), pg. 561

9 Ibid, pg. 576-577

District cooling systems most often use chilled water as a transfer fluid. Another option is an ice-water mixture that is transported at lower temperatures than chilled water. Lower fluid temperatures improve transportation efficiency and require less distribution infrastructure but reduce production efficiency.[10]

CENTRALIZED PRODUCTION

Most district energy systems have a form of centralized production. The largest source of waste heat in many communities is as a byproduct of electricity generation, which can be used as a heating source (cogeneration) and to power absorption chillers (tri-generation).

Cogeneration of heat alongside electricity is done at a combined heat and power plant (CHP) and can use most types of fuel, including coal, gas, and nuclear plants. This method can produce heat output in the scale of 10s to 100s of MWs.[11] However, if local electricity is already produced from low-carbon sources, such as renewables, the development of new CHPs can increase GHGs by increasing reliance on fossil fuels. This issue can be mitigated with the use of biomass.[12]

Tri-generation is the production of chilled water alongside electricity and heat in an integrated combined heating and cooling plant (CHCP). This process can be accomplished by using mechanical power from the plant turbine to run a compression chiller, or by using waste heat to drive an absorption chiller. Each method sacrifices some power output.[13]

DISTRIBUTED PRODUCTION

District heating systems may also use decentralized or distributed sources of heating and cooling. This allows the system to act as an energy broker that collects energy where there is an excess and supply it where there is a deficit. As distributed sources are typically lower grade (less hot or less cold), distributed systems may need to utilize electrical heat pumps to transfer energy between the network and source.[14]

District heating systems that use low-temperature heat sources must be water-based and have a relatively low distribution temperature. Examples of distributed heat sources include sewage treatment plants, manufacturing facilities, and natural or waste geothermal heat.[15]

Generally, buildings are cooled by extracting heat and rejecting it into the atmosphere from a cooling tower. The efficiency of this process is limited by the temperature difference between the tower and the atmosphere. However, district cooling systems can use existing heat sinks such as sewage water, lake water, or sea water. The ground can also be used as a sink but may become heated over the long-term and so is not an effective solution.[16]

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[10] Harvey (2012), pg. 579-580

[11] Ibid., pg. 565

[12] Ibid., pg. 563

[13] Ibid., pg. 572

[14] Ibid., pg. 578

[15] Ibid., pg. 578-579

[16] Harvey (2012), pg. 580

Benefits of District Energy

COST SAVINGS

District energy systems aim to deliver cost savings for customers by producing heating or cooling services more efficiently or from free sources. However, the efficiency savings of a district energy system must cover the high upfront costs of construction. Accordingly, district energy typically has a long payback period, particularly when energy costs are already low.[17]

The costs and revenues of a district energy system will vary significantly depending on the context of existing solutions, available heating and cooling sources, customer demands, and future projections.

Studies of financial feasibility provide an effective way to determine the payback period of a project.[18] This type of study examines the simple expected investment costs and cash flow of a project without discounting the time value to determine the internal rate of return. A financial feasibility study requires internal staff resources on financial projections and experienced economic analysis.

Studies of levelized unit energy cost compare per unit of energy costs across different system options.[19] A levelized unit energy cost study calculates total cost and energy production of a production asset to determine a concise value comparable to other technologies. This study requires only simple analysis if a feasibility study has already been completed, and is effective for comparing different district energy production methods.[20]

CLIMATE BENEFITS

The heating and cooling of buildings is a significant source of GHGs; buildings account for 19% of emissions in Ontario with heating from natural gas comprising the majority of those emissions.[21] District energy systems can reduce GHG emissions by reducing losses in energy conversion and by increasing the use of low-carbon energy.[22] This efficiency makes district energy an excellent method for cost-effective reductions in GHG emissions.

There are a range of methods available for benchmarking emissions reductions against economic costs; marginal abatement cost curves compare reductions directly to financial savings to determine potential impact and ease of adoption.[23] This can allow comparisons between municipalities and between projects within a municipality. As an example, Toronto's Transform TO report found district energy to have a marginal abatement cost of -163 $/tCO2e (dollars per tonne of carbon dioxide equivalent) with the

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17 Stephanie Cairns. "Methods for Measuring the Economics of Community Energy Plans: An Introduction for Community Energy Managers." Smart Prosperity Institute, December 2016. Retrieved from: http://institute.smartprosperity.ca/library/publications/methods-measuring-economics-community-energy-plans-introduction-community.

18 Ibid., pg. 9

19 Ibid., pg. 11

20 Ibid., pg. 12

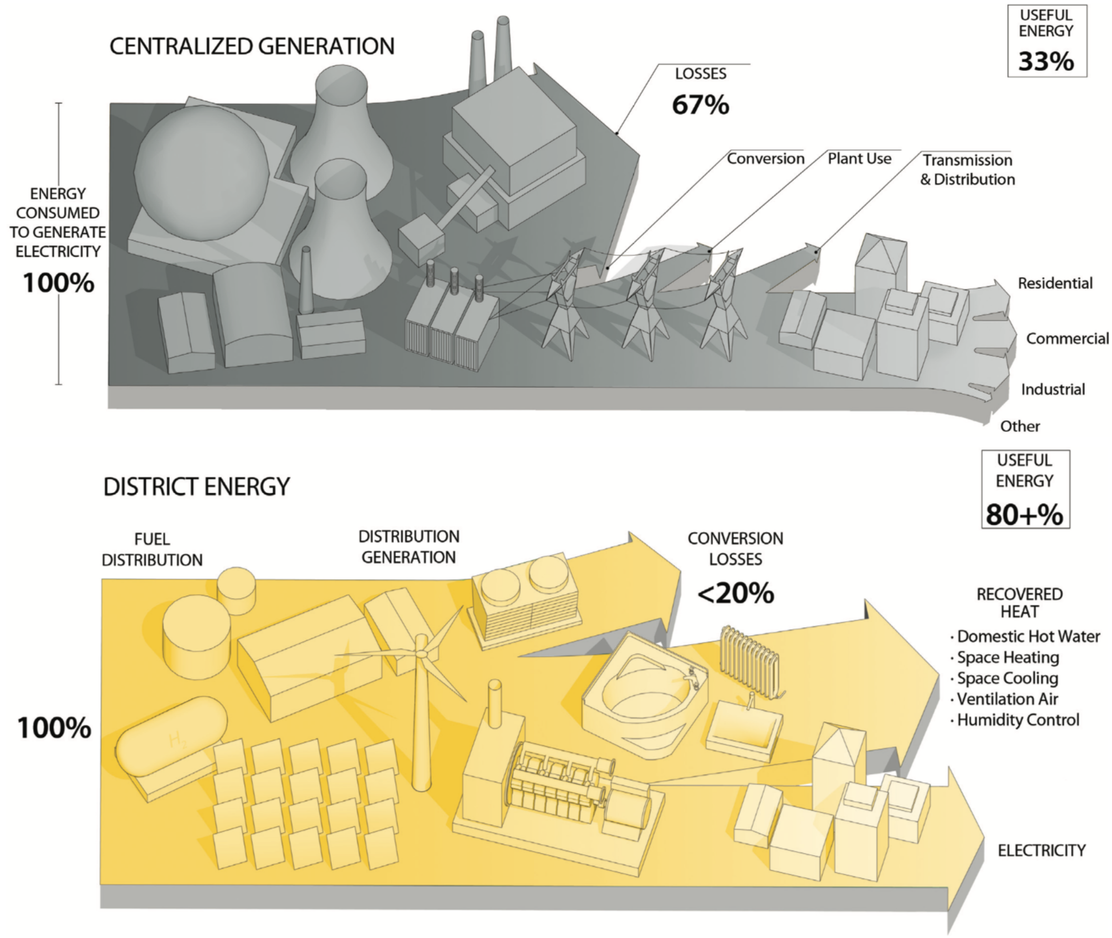
21 Environmental Commissioner of Ontario. "2016 Annual GHG Progress Report – Facing Climate Change," November 22, 2016. Retrieved from: https://eco.on.ca/reports/2016-facing-climate-change/. Pg. 44.

22 Harvey (2012), pg. 21

23 Cairns (2016)

potential to save a total of 22,390 kt (kilotonnes) CO_2e.[24] This was the second largest calculated source of emissions reductions with a negative abatement cost (after only increased electric vehicle adoption, which has smaller cost savings) in the low carbon scenario marginal abatement curve.

District energy developments also have the potential to lead to further reductions through positive feedback loops. By enabling the efficient transfer of thermal energy in a district, a district energy system can provide future energy integration opportunities, which may not be currently predictable.[25] However, district energy systems, if poorly planned, also pose the risk of locking a community into a system that is not adaptable to future technology. Risks such as over-investing in capacity, while energy efficiency retrofits are reducing demand,[26] or relying on uncertain supplies of renewable natural gas[27] are examples that can lead to increased emissions or reduced economic performance.



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24 TransformTO. "Results of Modelling Greenhouse Gas Emissions to 2050," April, 2017. Retrieved from: https://www.toronto.ca/wp-content/uploads/2017/11/91f6-TransformTO-Modelling-Torontos-Low-Carbon-Future-Results-of-Modelling-Gr....pdf. pg. 111

25 Ibid., pg. 133

26 Ibid., pg. 11

27 Ibid., pg. 125

Figure 2: Comparison of energy system efficiency with traditional heating (top) and DE (bottom)[28]

CO-BENEFITS

Beyond emissions reductions, district energy provides a number of co-benefits for communities, including resilience, livability, and local economic development. The most commonly cited co-benefit of district energy is increased community resilience. district energy systems can be flexibly designed by using distributed sources of energy production, allowing communities to avoid dependence on a single source or imported fuel supply. For a district energy system to be resilient, it must be designed to incorporate new and emerging technologies, including heat pumps and biofuels. This resilience can also benefit communities during extreme weather events or other disruptions to energy systems.[29]

District energy can have broad livability benefits for a community including saving space and maintenance concerns within the home, reducing noise or vibrations of building heating and cooling systems, and enhancing social capital through neighbourhood connections.[30] Thermal networks also can improve public health by decreasing air pollution within cities.[31]

The development of district energy systems can have significant local economic benefits. District energy infrastructure projects create new jobs and investment opportunities while also promoting innovation and firm competitiveness in new markets.[32] district energy systems can also generate local revenues that would otherwise go to fuel imports. The costs of district energy for consumers can vary. In the case studies explored below, costs were always competitive with individual home solutions, but were not necessarily lower. Impacts on equity can also be mixed, as economically disadvantaged populations may either be priced out of the district energy system or may receive access to previously unavailable heating and cooling, depending on specific circumstances.[33]

INNOVATION OPPORTUNITIES

District energy systems provide the opportunity to develop innovative solutions in energy storage, delivery, and integration, improving overall energy efficiency and helping jurisdictions to reach their decarbonization goals. Developments in smart grid technology, thermal storage, LTDH, renewable energy (RE) integration, district cooling efficiency, cost optimization based on efficient use of available sources, and loss reduction are all innovations being explored by jurisdictions at the forefront of district energy initiatives.[34]

In broad terms, smart grid innovation refers to the integration of smart technology to enhance management of energy demand, allowing for more efficient energy service at the production, delivery,

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[28] King, M. "Community Energy Planning: Planning, Development & Delivery, Strategies for Thermal Networks." QUEST, 2012. Retrieved from: http://www.questcanada.org/maps/cep-strat-for-thermal-networks.
pg. 4-5

[29] King (2012), pg. 6

[30] TransformTO (2017), pg. 91; Harvey (2012), pg. 575

[31] TransformTO (2017), pg.104

[32] Ibid, pg. 93, 99

[33] Ibid, pg. 82-84

[34] European Commission. Energy Research Knowledge Centre. *Smart District Heating and Cooling*. Brussels, 2014, pg. 42

and consumption stages. This allows for the monitoring of energy production and load through smart meters, and the optimization of energy use in order to smooth demand peaks. Smart grid technology can facilitate the thermal storage of energy when the supply of electricity or heating exceeds demand. Thermal storage can be done for short periods in thermal storage facilities and seasonally using underground thermal energy storage. This storage capacity allows district energy systems to help address the issue of intermittent renewable production, allowing increased integration of renewable energy into electrical grids. Given the distributed energy sources available in district energy systems, smart grid technology is essential for managing production and consumption more efficiently and cost-effectively.

As discussed under Climate Benefits above, district energy systems can utilize renewable energy as energy sources. Though fossil-fuel based heat generation is still the norm in many district energy systems, jurisdictions are increasingly implementing innovative sources including biomass, solar thermal energy, geothermal energy, waste-to-heat, and cooling from bodies of water.[35]

Improving energy efficiency of many new buildings also presents an opportunity for district energy innovation, as the decreased heat demand allows the use of LTDH without compromising service.[36] LTDH systems open further opportunities for low carbon energy as they can effectively use lower-grade heat and cold sources.

Case Studies

Research into the potential for district energy systems adoption in Ontario began with a case study analysis of some of the most successful district energy systems worldwide, exploring their characteristics, factors of success, and key innovations. The following section provides an overview of the methodology and results of this research, and gives a brief summary of the clearest lessons to be learned.

Methodology

A broad selection of 21 existing district energy systems was gathered from a review of previous case studies and meta analyses. These were narrowed to seven case studies based on three main criteria: policy enablers at the regional or national level, a market-viable financial model, and the provision of sustainability benefits.

A brief overview of the district energy systems is provided in Table 1 below, in-depth analysis of each system is available in the Appendix (Case Studies). This overview highlights factors identified as key to meeting municipal and national goals on climate change action and energy system resiliency:

1. The size of the system determines its overall economic, social, and environmental impact. Small systems have a capacity less than 10 MW, medium systems have a capacity less than 100 MW, large systems have a capacity less than 1000 MW, and very large systems have a capacity greater than 1000 MW.

[35] Galindo Fernández, M., Roger-Lacan, C., Gährs, U., Aumaitre, V. , Efficient district heating and cooling systems in the EU - Case studies analysis, replicable key success factors and potential policy implications, EUR 28418 EN , doi: 10.2760/371045, pg. 11

[36] European Commission (2014), pg. 10

2. The policy at the highest level of government that had a significant role in the success of the initiative is listed under policy enablers.

3. The ownership model of the system and the market model are listed. The ownership models seen were public-private partnerships (P3), municipally-owned companies (municipal), and customer-owned cooperatives (cooperative). Markets were either regulated with mandatory connection, or left in relative competition.

4. The main fuel source used is included to demonstrate the role of each system in utilizing different types of often-renewable energy.

Results

Table 1: Select results on the seven district energy systems covered in the case studies

City	*How large is the system?*	*Are there policy enablers?*	*What is the ownership model?*	*What is the main fuel source?*
Barcelona	DH: Medium DC: Medium	National Energy Efficiency Plan	P3, Competitive market	Biomass
Brescia	DH: Large DC: Medium	Municipal-led	P3, Competitive market	Natural Gas
Copenhagen	DH: Very Large	National, Heat Supply Act	Municipal/cooperative, Mandatory connection	Biomass
Gram	DH: Small	National, Heat Supply Act	Cooperative, Mandatory connection	Solar Thermal
Hamburg (HafenCity)	DH: Small	National, Combined Heat and Power Act	Municipal, Mandatory connection	Biogas
Mannheim	DH: Very Large	National, climate change policy	Municipal, Mandatory connection	Biomass and Waste-to-energy
Stockholm	DH: Very Large DC: Large	National, District Heating Act	P3, Competitive Market	Waste-to-energy

Key Takeaways

Several recurring features were observed throughout the course of research. First, district energy systems have been highly successful in a variety of jurisdictions with variable environmental contexts, different policy frameworks, and distinct ownership schemes. All the jurisdictions reviewed had nonetheless found that district energy systems improved overall energy efficiency in their cities and helped them towards their energy goals. Secondly, successful district energy systems were most often initiated by distinct district energy policy. This policy may have been implemented at the national level, such as those found in Denmark, or by municipal level initiatives, such as those implemented by the Brescia city authority. Those jurisdictions operating under national level policy were observed to have the most expansive district energy systems. Policies were usually initiated with the aim to reach goals such as energy resilience, energy efficiency, or climate change mitigation. Thirdly, initial investment costs in district energy were high regardless of existing energy mix, so access to resources was a key driver for the implementation of district energy systems. Finally, district energy systems have been a key enabler in the integration of innovative de-carbonization solutions, including renewable energy use, thermal storage implementation, and smart grid initiatives.

Applications to the Ontario Context

District Energy Systems in Ontario

Ontario has at least 43 district energy systems across the province (as identified by the Canadian Energy and Emissions Data Centre or CEEDC),[37] demonstrating strong municipal interest in and local support for district energy development. Table 2 below provides an overview of 17 select district energy systems in Ontario. The identified district heating systems primarily use natural gas as fuel and steam for distribution; the district cooling systems also predominantly use natural gas as fuel and use water for distribution. This overview does not include some more innovative projects, for example the Enwave district energy system in Toronto and the McMaster Innovation Park district energy system in Hamilton. The Enwave system includes a traditional natural gas fuelled steam district heating system and a newer deep lake water cooling (DLWC) district cooling system that transports water cooled from Lake Ontario.[38] McMaster's Innovation Park has a centralized fluid-based distribution system that uses renewable technology including solar thermal panels and cooling towers for energy production.[39]

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[37] CIEEDAC. "Map of Facilities in Our Database." Simon Fraser University (blog). Accessed April 12, 2018. Retrieved from: http://cieedacdb.rem.sfu.ca/data-overview/.

[38] Enwave. "Enwave Facilities," 2013. Retrieved from: http://enwavetoronto.com/facilities.html.

[39] MIP. "Sustainable Design." McMaster Innovation Park. Accessed April 12, 2018. Retrieved from: https://mcmasterinnovationpark.ca/sustainable-design.

Table 2: District energy systems in Ontario with data on thermal network capacity

System Name	City	Year	Number of Buildings	DH Capacity Steam (MW)	DH Capacity Water (MW)	DC Capacity Water (MW)
Hamilton Community Energy	Hamilton	2002	11	-	12.00	0.70
Queen's University	Kingston	1930	100	202.00	-	-
London District Energy	London	1880	50	76.00	-	9.00
Cornell Centre	Markham	2012	6	1.00	15.00	14.00
Markham Centre	Markham	2000	32	-	31.00	36.58
C100 - Central Plant	Nepean	1970	6	0.35	7.03	3.87
Confederation Heights District Energy System	Ottawa	1950	11	-	46.90	17.50
PWGSC Heating and Cooling Plants	Ottawa	1910	85	295.00	-	172.00
RCMP District Energy System	Ottawa	1970	4	15.60	-	6.00
Tunney's Pasture District Energy System	Ottawa	1950	18	93.80	-	40.70
University of Ottawa Power Plant	Ottawa	1970	33	73.27	-	23.20
Beaver Barracks	Ottawa	2010	5	-	3.00	0.70
Sudbury District Energy - Downtown	Sudbury	2000	7	-	4.55	1.55
Regent Park Community Energy System	Toronto	2009	-	11.00	-	8.26
District Energy Windsor	Windsor	1996	10	19.20	19.60	20.74
Windsor University Cogeneration Plant	Windsor	1993	-	4.32	-	16.88
Total				**791.54**	**139.08**	**371.68**

Ontario District Energy Policies

Currently, there is no explicit provincial-level policy for district energy systems in Ontario. However, there are policies in place that provide support for district energy indirectly. The following overview of relevant policies is not exhaustive.

Ontario's Long-Term Energy Plan:[40] This 20-year roadmap for Ontario's energy sector (published in 2017) is a consumer-focused plan striving to make energy more affordable, reliable, and innovative. The plan mentions district energy systems briefly as a means to reduce GHG emissions in a cost-effective manner, particularly in the initial stages of new developments.

[40] Government of Ontario. "Ontario's Long-Term Energy Plan." Text. Ontario.ca, October 25, 2017. Retrieved from: https://www.ontario.ca/page/ontarios-long-term-energy-plan.

Ontario's Climate Change Action Plan:[41] Ontario's five-year plan to address climate change by reducing greenhouse gas emissions and transitioning to a low-carbon economy highlights the significant GHG impact of building heating and industrial activity. The plan does not specifically identify district energy as an opportunity for reducing emissions. However, the Municipal GHG Challenge Fund, a Climate Change Action Plan initiative to support community-led action on climate change with funds from the carbon market, does identify district energy as potentially eligible for funding.[42]

Other Project Funding: District energy projects have also received funding from other sources in Ontario. For example, Sheridan College received a $2.6 million investment from the Ontario government to support its district energy project (along with $9.9 million from the federal government through the Postsecondary Institutions Strategic Investment Fund).[43] Infrastructure Ontario also provides loans to municipalities and "municipal corporations", including district energy corporations.[44] In 2012, for example, nearly $19 million in loans were provided for district energy projects.[45]

Policy Opportunities for District Energy in Ontario

Ontario's unique political context and energy systems present many opportunities for the implementation of successful district energy projects in the province. The case study analysis revealed that district energy systems have the potential to provide a significant amount of the heating (and cooling) for a diverse range of cities, with a variety of energy make-ups. While many of the jurisdictions examined in the case study had a higher load density than what exists in most North American cities, this is not necessarily a barrier to district energy development. Regions with higher load densities are better suited to a centralized approach, while those with low load densities are best suited to the distributed approach.[46] This presents an opportunity in the Ontario context, as distributed systems will also allow for a more flexible and resilient energy network that can more easily integrate technological improvements.

Additionally, district energy presents solutions for unique challenges faced by energy consumers in many Ontario municipalities. The current energy system used in Ontario has created vulnerabilities in regards to energy delivery. For example, reliance on a few, centralized power generation systems may result in major vulnerabilities in the face of extreme weather patterns. The ice storm which affected the power supply of southern Ontario and parts of Quebec in 2013, for example, demonstrated the

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[41] Government of Ontario. "Climate Change Action Plan." Text. Ontario.ca, May 20, 2016. Retrieved from: https://www.ontario.ca/page/climate-change-action-plan.

[42] Government of Ontario. "Grants Ontario: Municipal GHG Challenge Fund," November 17, 2017. Retrieved from: http://www.grants.gov.on.ca/GrantsPortal/en/OntarioGrants/GrantOpportunities/PRDR017538.

[43] Community Energy Knowledge - Action Partnership. "Sheridan College District Thermal – Partnering Across Boundaries." CEKAP, 2016. Retrieved from: http://www.cekap.ca/resources/research-report-OCC_Brampton%20Sheridan%20College-Report-rvApr27.pdf

[44] Canada. Ministry of Economic Development, Employment and Infrastructure. Office of the Auditor General of Ontario. *Chapter 3: Infrastructure Ontario's Loans Program, 2014 Annual Report of the Office of the Auditor General of Ontario.* Retrieved from: http://www.auditor.on.ca/en/content/annualreports/arreports/en14/306en14.pdf

[45] Canada. Infrastructure Ontario. *A Year of Transformation Annual Report 2012-13*. 2013. Retrieved from: http://www.infrastructureontario.ca/WorkArea/DownloadAsset.aspx?id=34359739678

[46] Mikler, Vladimir. *District Energy 101*. Report. Integral Group Vancouver. Retrieved from: https://www.integralgroup.com/wp-content/uploads/2017/06/IntegralGroup_District-Energy-101.pdf.

consequences of such a vulnerability. Decentralized district energy systems provide the opportunity to create resilient energy systems that will continue to provide services to communities which are affected by extreme weather conditions.

Ontario's municipalities have already expressed interest in district energy for these reasons and have either explored opportunities or initiated development. district energy should be supported by the Ontario government in a way that ensures that municipalities, regardless of the unique direction they choose to take, implement initiatives that will ultimately support Ontario's overall energy goals. Ontario should support district energy systems which are decentralized, integrate sustainable energy sources, and are flexible to future innovations and technological advances. The Ontario government is well-placed to encourage local communities to take the lead on energy efficiency and resiliency projects through district energy, while still contributing to Ontario's overall climate change mitigation goals.

PROVINCIAL DISTRICT ENERGY FRAMEWORK

While stakeholders interviewed believe that most policy decisions about district energy projects should be made at the municipal or project level, some key components of development are impacted by provincial policy and could benefit from increased clarity. Additionally, there is a significant knowledge gap between Ontario and regions with more experience in district energy, such as Denmark or Sweden. Leadership at the provincial level could facilitate the sharing of information between stakeholders interested in district energy, rather than dictating the terms of district energy projects.

As discussed in the case studies, Denmark and Sweden have developed national-level policies on district energy that have facilitated widespread adoption of district energy systems. Differences between the policies in these two countries indicate that there are a range of options for regional level policy on district energy. Ontario can learn from these jurisdictions to adopt policies that support its goals in climate change mitigation and community resilience.

Sweden's District Heating Act,[47] for example, prioritizes transparency, requiring operators to publish annual financial statements.[48] A complementary District Heating Board mediates negotiations between companies and customers. The act has received criticism from market stakeholders for not allowing third party access.[49] This is a good basis for policy in Ontario, where freedom of choice and market clarity will be essential factors for political feasibility of policy.

In comparison, Denmark's Heat Supply Act includes more stringent regulations, allowing the Ministry of Energy to ban the use of electric heating in buildings with access to district heating and to enforce obligatory connection.[50] The Act also includes provisions setting forth principles for cogeneration and heat pricing. This has led to highly successful projects in Denmark but similar policies are unlikely to be politically viable in Ontario.

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[47] Government of Sweden. "District Heating Act." January 1, 2012. Retrieved from: https://www.ei.se/Documents/Publikationer/lagar_pa_engelska/District_Heating_Act.pdf

[48] Werner, Sven. "District heating and cooling in Sweden." Energy 126 (2017): 419-429.

[49] Ibid.

[50] IEA. "Denmark | Heat Supply Act," November 25, 2014. Retrieved from: https://www.iea.org/policiesandmeasures/pams/denmark/name-21778-en.php.

IMPROVE COLLABORATION IN GOVERNMENT AND ACROSS SECTORS

The development of a district energy system is a major project that involves a wide range of stakeholders and policies. An integrated policy approach and collaboration among developers and customers have been identified as key contributors to the success of district energy systems in Europe.[51] The Ministry of Energy could support district energy in Ontario by facilitating cooperation between a range of stakeholders.

Multiple provincial ministries play a role in district energy projects. Systems must be compatible with the building codes established by the Ministries of Municipal Affairs and Housing. Building codes can encourage new building developments to reduce GHG emissions and maintain compatibility with connections to district energy systems. The Ministry of the Environment and Climate Change is responsible for leading the delivery of cap and trade proceeds through initiatives including the Green Ontario Fund and the Municipal GHG Challenge Fund, which could be used to support district energy projects. Energy efficiency and smart grid initiatives are run through the Ministry of Energy. Communication of common goals of and opportunities for district energy between these ministries could help support the market for district energy and align interests between the province, municipality, and customer.

Policymakers should also seek to collaborate with leading companies and expert non-profit organizations to facilitate the sharing of practical knowledge. System owners and operators include the Canadian government in Ottawa, universities across the province, and corporations including Enwave Energy Corporation. Collaboration between market participants has led to more efficient systems and greater interconnections with neighbouring thermal networks in Europe.[52] Research groups including QUEST, based in Ottawa, and the Canadian Energy and Emissions Data Centre (CEEDC), at Simon Fraser University, provide resources including systems overviews and may help provide essential heat mapping services in the future.

FUNDING

Financial support for district energy is another key element of project development in Ontario. Most of the case studies analyzed had been supported by some project financing assistance from federal or lower-level government initiatives, and many professionals interviewed cited financial assistance as being key for planning projects and, in particular, in exploring innovations. As mentioned previously, some funding has been made available to district energy projects through policies such as the *Climate Change Action Plan*, which initiated the Municipal GHG Challenge Fund. Loans are also available through Infrastructure Ontario's Loan program. As a potential limitation, revenues from the cap and trade program are used for mitigation efforts, rather than adaptation, thus limiting their application to district energy projects. In addressing the issue of funding for municipalities, the role of the Ontario government may be to highlight which funds are available for district energy projects, and to provide clarity to municipalities in regards to where they can access these resources.

NEXT STEPS

This report revealed some key areas for further research. One main question from stakeholders is the economic viability of implementing district energy systems in Ontario's municipalities. Given the wide variation in costs of implementing district energy systems based on factors including local energy supply

[51] Fernández et al., pg. 127, 131

[52] Fernández et al., pg. 131

and demand, costs are difficult to generalize within the scope of this report. Further research should identify cost ranges and assess the factors that contribute to their variation in different municipalities across Ontario. This research should also identify best practices in regards to cost-effectiveness to ease research for municipalities where lack of resources may be an issue. Further research could also contextualize the economic benefits of implementing district energy systems in Ontario. district energy projects can have major economic benefits in regards to improving local economies, and this factor can potentially be a major driver promoting district energy.

Additionally, next steps should be taken to explore methods for avoiding the issue of lock-in, where district energy systems may become less sustainable than new technologies, but too costly to abandon. Methods for implementing district energy in a way that ensures future flexibility would be valuable and could learn from leading projects in Europe. Furthermore, understanding the extent to which the knowledge gap in technical district energy experience exists would help policy makers in Ontario implement strategies for improving technical knowledge and promoting innovative district energy systems, through initiatives such as job training and employment development, or collaboration with research institutions.

District energy presents an opportunity to establish policy at the provincial level that incorporates stakeholders across different sectors and ministries to reach goals for climate change mitigation and community resilience. Policy that frames these goals through the integration of thermal and electrical energy systems can pave the way for future energy systems integration innovations. New approaches will be required for important goals in Ontario including increasing the penetration of renewable energy and incorporating electric vehicle batteries into the grid. Clear policy on district energy systems can lay the groundwork for these approaches while helping cities and the province meet their climate goals.

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Appendix: Case Studies

Copenhagen[53]

OVERVIEW

Greater Copenhagen boasts one of the largest district energy systems in the world, with nearly 1 million people in Greater Copenhagen's 25 municipalities (and 0.5 million people in Copenhagen) being served by district energy. With three privately owned transmission companies, and 24 consumer- and municipal-owned distribution companies, the district energy represents a system built on successful collaboration between multiple actors, optimizing efficiency and accountability. The Danish government has also promoted commitments to environmental sustainability, leading to the integration of renewable energy sources, with 30% of the current system fueled by biogas.

POLICY DRIVERS

Motivated by the goal of decreasing dependency on imported oil in the early 1970's, the Danish government established policy frameworks which have also spurred the development of district energy projects from the early 1970s towards the 1990s. As environmental issues became a priority in the 1990s, the government also developed project proposal mechanisms for municipalities, which required them to ensure projects would provide the most cost-efficient heating supply option, in order to stimulate the transition from natural gas to district heating. This policy ultimately culminated in the Energy Policy Agreement of 2012, setting aims for Denmark to become completely independent of fossil fuels by 2050.

These goals have laid foundation for strong policy which has stimulated the development of a resilient energy supply. The Heat Supply Act, enacted in 1979, aims to accomplish two main goals: one, to promote socioeconomic and environmental performance in the heat and hot water supply of buildings, and two, to promote the use of combined heat and power (CHP) generation. This act has since set the stage for governing principles, upon which district heating systems in Denmark currently operate. The non-profit principle states that all district heating companies must be non-profit, as well as cooperatively owned and governed. As a result, return on invested capital is limited at 7-8%, and the price of heat must be limited to whatever is necessary in order to cover the costs of production and distribution to end users. The strategy of all district heating companies in Denmark is to provide high-quality service, to reduce the cost of heating as much as possible, and to reduce $CO2$ emissions. The Act also relays heat zoning responsibility to municipal councils, who must make decisions on heat planning on 20-year cost-benefit analyses, must consider environmental externalities, and follow a specific methodology established by the Danish Energy Agency. The protection of consumers falls under another important principle established by the Act, whereby the Danish Energy Regulatory Authority oversees the fair operation of district heating companies by requiring them to submit information on prices and conditions in order to deal with complaints and objectives, and in order to benchmark prices amongst companies and prevent discrepancies for consumers. Finally, the Act outlines a general ban on electric or oil boilers, and details a preference for combined heat and power (CHP) plants for new heating capacity generation.

[53] Fernández et al., pg. 13-25

FINANCIAL VIABILITY

To promote the energy transition, the Danish government implemented investment subsidies for energy efficient systems, CHP, and renewable energies during the 1990s. Those subsidies were slowly transitioned out and replaced with incentives to improve district energy markets, such as a "capacity credit", which is given to decentralized CHP plants that operate in the electricity market, and an electricity production subsidy for gas and waste-fueled plants. As of this year, this premium will only be given to CHP plants using renewable energy. Alongside subsidies and incentives, the Danish government has also implemented taxes and tax exemptions to support the development of CHP and district heating systems.

The Danish government also offers competitive loans for district heating projects, offering interest rates of only 1%. Funds are also available through the *Kommune Bank*, which offers enough long-term debt funding that finances 100% of municipalities' district heating investments, through a municipal guarantee. District cooling projects are also offered competitive loans, though there is a higher interest rate given the relative uncertainty of success and lack of municipal guarantees. Consumer-owned companies are able to finance debts at interest rates of 2-3%, while municipality owned companies finance their projects independently from the national government, using revenues from selling their electricity grid.

CO-BENEFITS

The Danish commitment to energy efficiency has created a number of co-benefits in the development of district energy systems. For example, the integrated approach of interconnection in the network and a diversified energy mix based on CHP, heat storage capacity, and the daily optimization of heat and electricity production has created a highly flexible system which will be better able to integrate renewable energy sources into the system, as those sources become more viable. These commitments have also resulted in a strong framework for innovation among district energy companies, which have worked together with research institutions to develop projects on deep heat storage, large-scale solar water heating, and no-dig methods for pre-insulated pipes, amongst others. Copenhagen is now one of the leading jurisdictions in the use of "smart solutions," aiming to increase efficiency of public services and improve quality of life of citizens.

Gram[54]

OVERVIEW

As another Danish jurisdiction, Gram operates within the same policy framework detailed for Copenhagen above, but represents the successful integration of innovative technologies that allow for increased renewable energy use. Using solar district heating with seasonal storage pits, the system established in Gram allows for cost efficient and flexible heat supply through renewable sources, reducing fossil fuel use while maintaining high quality service for end-users.

POLICY DRIVERS

Denmark's environmental sustainability commitments have, in general terms, resulted in the successful implementation of renewable energy sources in Gram. In regards to Gram specifically, a number of policy measures have ensured the success of its innovative energy solutions. For example, governance of the system is achieved through the sustained cooperation between the municipality, the district heating company, potential users, and final users. The cooperative is represented by a board which includes

[54] Fernández et al., pg. 26-35

representatives from the municipality and from final users, who aim to improve the system's efficiency. Additionally, the system connects the electricity and heating markets, which is enabled by the seasonal storage pits that allow for the integration of renewable sources – wind and solar.

FINANCIAL VIABILITY

Ensuring the competitiveness of district heating systems begins, as mentioned for the Greater Copenhagen region discussion above, with the project planning stage. This step applies the national framework for district heating, has access to competitive debt funding, and utilizes a long-term planning approach. Such long-term vision for Gram has resulted in increasingly cost-efficient system, which has resulted in the reduced the average price of district heating supply by 16.5% from 2016 to 2017.

The solar district heating project in Gram was financed through the *Kommune Bank* mentioned above, with investment recovery ensured through heat sales.

CO-BENEFITS

Climate co-benefits represent the major success of Gram's solar district heating system. The competitiveness and flexibility of Gram's system has resulted in a highly efficient technology which has allowed district heating companies to reduce their fossil-fuel dependence, at the same time ensuring stable service to their clients. Currently, 62% of Gram's fuel sources used for heat production comes from direct solar heating, and is combined with a seasonal storage pit that allows for a high degree of operational flexibility in the district heating system, loading heat in the summer months and off-loading in the winter.

Stockholm[55]

OVERVIEW

Stockholm has an extensive and well-developed district energy system with an 80% market share of heating and a smaller, but growing, district cooling component. The system supplies 10,000 clients across six municipalities. The traditionally public model has recently opened up widely to public-private partnerships with the system now half-owned by the City of Stockholm and half-owned by Fortum Heat & Power. The district energy system has ambitious environmental targets with the goal of climate- and resource-neutrality by 2030.

POLICY DRIVERS

There are a range of regulatory policies and public finance initiatives in place in Sweden and Stockholm that have helped encourage the adoption of district energy. Sweden has a District Heating Act along with transparent price benchmarking that provide clear and transparent rules for the market. This also provides a level of price predictability that makes investment in expensive district heating projects more attractive.

There have been both direct and indirect financial incentives to district energy systems. Taxes on CO_2 emissions, sulphur emissions, and fossil fuel energy production all encourage customers to use low-carbon heating. Furthermore, tax reductions are available for households to reduce their environmental footprint, including by connecting to district heating systems. Direct subsidies were in place from 2006 to 2010 to support conversion from oil or electrical heating to district heating. Subsidies to combined heating and power also encourage the production of heating at a district level.

[55] Fernández et al., pg. 111

FINANCIAL VIABILITY

Stockholm's district energy system is a public-private partnership (PPP) owned and operated by Fortum Värme AB, which is in turn owned 50% by the City of Stockholm and 50% by Fortum Heat & Power. While Fortum Värme AB is the main district heating supplier, it also collaborates with the neighbouring systems of Söderenergi and Norrenergi by maintaining grid connections and optimising production through common heat dispatch.

Stockholm's district energy system is highly cost-competitive with alternatives: primarily household electric heat pumps. The city has very low electricity prices, enabling the high competition between district and individual heating systems. Collaboration between the public and private sectors and among thermal grids with independent owners has allowed the district energy system to remain market-competitive. It primarily uses local resources including waste and bio-fuels, providing a secure long-term supply for production.

CO-BENEFITS

Climate benefits of the district energy system are significant. The dominant use of renewable low-carbon sources for heat production – primarily waste-to-energy, biomass and electrical heat pumps – results in low emissions of 0.136 kg/MWh. The district cooling system is entirely carbon neutral, relying primarily on free cooling from water bodies.

There are a variety of innovative research and development projects underway in Stockholm aimed to further reduce the environmental impact of the district energy system. The Open district heating business model is designed to connect data centres to the thermal network as heat sources and cooling customers. The Hammarby Stöstad and Stockholm Royal Seaport eco-districts are regional projects focused on further reducing local environmental impacts through technologies including district energy and are incorporating smart grid technology to better manage their impact.

Hamburg[56]

OVERVIEW

Hamburg's HafenCity district, currently undergoing modernisation development, is building a district heating system to be run on low-carbon biogas. Currently at a small scale, with a heating capacity of 7 MW, the system is planned to produce at 48 MW by completion in 2024. The privately-owned district heating system has benefited from strong support by the city of Hamburg and an obligatory connection policy.

POLICY DRIVERS

Germany does not have any regulations that specifically encourage or support district heating. However, a range of environmentally progressive national policies encourage district heating, based on the German policy for energy transition (Energiewende) which sets significant CO_2 emission goals. The Renewable Heat Act and Energy saving ordinance require levels of renewable energy use and efficiency in heating that are met effectively by district heating systems. The Combined Heat and Power Act also prioritizes thermal network connections to CHP plants.

Financial incentives are also in place that further support district heating development in Germany. The Combined Heat and Power Act provides subsidies for the installation of district heating grids and a premium price on power generated by CHP plants. Additionally, the national public bank KfW supports

[56] Fernández et al., pg. 69-81

investments in district heating systems that use renewable energies through low interest rate long-term financing and investment grants.

FINANCIAL VIABILITY

HafenCity's district heating system is privately owned and operated by eCG Nord. The selection by the city was a preferred bidder process that mandated competitive costs and CO_2 emissions below 125g/kWh. Good coordination between eCG Nord and the city of Hamburg has been essential to the project.

The district energy system is cost-competitive with alternatives, particularly natural gas. However, the system has a mandatory connection policy that effectively eliminates competition in the HafenCity district.

CO-BENEFITS

The HafenCity district heating system is an effective example of the use of biogas as a renewable and low-carbon heat production fuel. The proposed final emission profile is 89 g CO_2 / kWh, utilising biomethane and natural gas CHP, biomass heating, and a heat pump.

The system owner has studied the possibility of connecting a nearby copper-producing plant to the network, which could significantly decrease production requirements and CO_2 emissions. This would have further co-benefits of improving air quality in the district by removing the need for a heating station and decreasing environmental disruption in the nearby river that is currently used as the heat sink for the plant.

Mannheim

OVERVIEW

District heating has been in use in the Mannheim since 1959, and now provides heating to over 80,000 homes and most non-residential buildings.[57] The district energy system has allowed for significant GHG reduction, with the reduction of about 300,000 tonnes of CO2 in 2015.[58] Mannheim's district energy system was chosen for its record of exploring innovative solutions in conjunction with its district energy projects.

POLICY DRIVERS

Mannheim's district energy development occurred under the same national policy drivers as those described for Hamburg; there were no specific policies for district energy development, but financial incentives for energy efficiency projects played an important role. In Mannheim specifically, the municipal government has taken its own initiatives for reaching climate change goals, implementing the *Mannheim on Climate Pathway* Strategy.[59] This initiative outlined the aim to reduce local CO2 emissions by 40% by 2020, and outlined sustainable district energy development as a key activity in helping to reach this goal. Additionally, some initiatives such as the Mannheim E-Energy Technology Competition,

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[57] *District Energy Strategic Plan for the City of Guelph* (pp. 8, Rep.). (2013). Guelph: City of Guelph. Retrieved from http://guelph.ca/wp-content/uploads/011514_DistrictEnergyStrategicPlan_web.pdf

[58] Grosskraftwerk Mannheim Aktiengesellschaft. *Reliable Energy for Mannheim and the Region*. Grosskraftwerk Mannheim AG, 2015. http://www.gkm.de/media/?file=314_gkm_image_brochure_en.pdf&download.

[59]"Model City Mannheim (Moma)." Grid Innovation Online. Accessed April 11, 2018. http://www.gridinnovation-on-line.eu/articles/library/model-city-mannheim-moma.kl.; *Mannheim on Climate Pathway* (Publication). (2015). Mannheim: Stadt Mannheim; Kllmaschutzagentur.

which resulted in the "Energy Butler" development, was the driver in the city's innovative smart grid solutions.[60]

FINANCIAL VIABILITY

The system is owned and operated by the city-owned utility MVV Energie, and has now established itself as a competitive supplier of district heating, with prices that are cheaper than gas and fuel oil. The utility also provides the city with electricity, natural gas, and water and sewer services in addition to district energy, but district energy is the most profitable product.[61] To attract customers to the district heating grid, the utility introduced an incentive program which would provide customers with a bonus for every kW connected to the grid, as well as a lump sum for every oil tank removed.[62]

CO-BENEFITS

As mentioned previously, district energy has allowed for developments in smart grid technology, and has also provided significant economic benefits to the city's residents. In regards to smart grid technology, the city utility, MVV Energie, has developed projects such as the "Internet of Energy", where customers can adapt their energy requirements to renewable energy production online. The results from the project are now being used for German-wide research and development.[63] Additionally, the "Strombank" project allows customers to store and stagger their electricity use from decentralized generation sources. Beyond innovation, the city's district energy developments have led to significant inputs into the local economy, with EUR 50M having been invested in the city for district heating development, to mostly local contractors.[64]

Barcelona[65]

OVERVIEW

Barcelona has two successful district energy systems, Districlima and Ecoenergies, that together provide about 100 MW of heating and 50 MW of cooling in the city. The Ecoenergies system, which is under continuing development, is our focus for its innovative modular design that emphasizes flexibility. The system is owned under public-private partnership and utilises smart grid technology for real-time energy management and optimisation and progressive energy sources including biomass for heating and surplus cold recovery. It has been supported by a national energy efficiency plan and a premium tariff scheme supporting CHP and renewable production.

POLICY DRIVERS

The success of district energy in Barcelona has been supported by policies at all levels of government. At the national level, the National Energy Efficiency Plan provides funding including access to EU funds. The

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[60] "Model City Mannheim (Moma)." Grid Innovation Online

[61] City of Guelph (2013), pg. 8

[62] District Heating and Cooling, Combined Heat and Power and Renewable Energy Sources | Best Practices Survey | Country Survey (pp. 1-143, Publication No. A044924). (2014). Nuorkivi Consulting, COWI. Retrieved from http://basrec.net/wp-content/uploads/2014/11/DHC_CHP_RES_survey_BASREC_Countries.pdf

[63] "Mannheim Becomes One of the World's Smartest Cities." The New Economy. Accessed April 11, 2018. https://www.theneweconomy.com/business/mannheim-becomes-one-of-the-worlds-smartest-cities.

[64] Nuorkivi Consulting, COWI (2014), pg. 128

[65] Fernández et al., pg. 94-104

city's district energy systems were originally supported by a feed-in tariff scheme. This was replaced in 2014 by a national premium tariff scheme that reduced the total financial support for both CHP and renewable electricity production. The Ecoenergies project has been championed by the autonomous region of Catalonia, which has its own Energy and Climate Change Plan.[66]

FINANCIAL VIABILITY

Barcelona's Ecoenergies system is owned in public-private partnership in a special purpose vehicle (SPV) by Barcelona City Council (17.55%) and the private companies Veolia (72.45%, also the system operator) and Copisa (10%). The project will in total require an investment of approximately EUR 105 million. Currently the separate district energy systems are not connected. This is seen as an opportunity for further efficiencies and is part of the next phase of the Ecoenergies modular development plan.

The system is cost competitive with alternatives, which are typically individual home natural gas heating and electrical cooling. The district heating and cooling systems operate at costs from 5-12% less than individual systems. However, connection fees are paid by customers and connection is not mandatory.

CO-BENEFITS

The Ecoenergies system is particularly notable for the innovative steps being taken to improve its flexibility and reduction of carbon emissions. The heating system currently does have significant carbon emissions at 94.9 kg/MWh, using natural gas and biomass for energy. Opportunities for reduction will be realised as greater interconnections are made between thermal networks. The district cooling system uses cold production facilities and is developing innovative surplus cold recovery from an LNG terminal. This will be accompanied with ice storage facilities and a new cooling network that aim to operate the district cooling system as completely carbon neutral.

Modular implementation has been a central priority in the planning of the Ecoenergies system. Its development began in 2012 and is scheduled to finish in 2024. The first stage consisted of building out heating and cooling capacity and diversifying land use to incorporate residential buildings alongside industrial zones, allowing for greater thermal connection opportunities. The second stage is the incorporation of the LNG regasification plant and storage facilities to improve the efficiency and capacity of the cooling network. The final stage that will continue into 2024 is the expansion of the Ecoenergies network further across Barcelona. This flexibility is complemented by smart grid technology. Every connected building uses smart meters and consumption is based on real time energy use, supporting efficiency improvements and awareness.

Brescia[67]

OVERVIEW

Brescia became the first Italian municipality to develop a district heating system in the 1970s when the municipal government established goals to integrate energy and waste management systems. Since then, 70% of the town's heating is supplied by district heating, with fuels mainly obtained from a local CHP waste-to-energy facility. The system's success can be largely attributed to the strong support provided to district heating by the municipality, which, through the use of a public-private partnership ownership

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[66] Generalitat de Catalunya. "Energy Plan and Climate Change in Catalonia 2012-2020." Start, April 25, 2012. Received from: http://canviclimatic.gencat.cat/en/politiques/politiques_catalanes/la_mitigacio_del_canvi_climatic/pla_energia_i_canvi_clima_2012_2020.

[67] Fernández et al., pg. 83 - 93

structure, has integrated local fuel sources and undertaken innovative projects to improve the quality of the overall service.

POLICY DRIVERS

National policy specific to district heating is absent in Italy, and incentives for municipalities to develop district heating systems is limited to white certificates – which are tradable on the market – and a reduced value-added tax for heat sales to residential consumers using renewable energy sources or CHP. Specific grants for district heating projects are entirely absent, and the heating market is not regulated at the national level. As such, mandatory connection to a district heating grid is impossible to enforce, and consumer choice in heating sources is made largely on the basis of cost-reduction.

In the absence of specific policy initiatives from the Italian government, the main factor for success of district heating systems in Brescia has been the strong support provided by the municipality, who, in the 1970s, aimed to integrate public services provided by the municipal utility responsible for power and gas distribution, water treatment and sewage, street cleaning, and other services. For this aim, the municipality established the utility *Azienda dei Servizi Municipalizzati,* which developed a project for a new CHP plant in the early 1960s, and worked with the municipality on a long-term plan for the development of a district heating grid and heat generation facilities. This plan resulted in the commissioning of a district heating system in 1972, development of new CHP units, establishment of waste-to-energy CHP plant, and integration of heat recovered from a nearby steel factory. Under the ownership of the municipal utility, the district heating grid was expanded to existing urban areas. The system was conceded to A2A Group in 1996, but remains partially owned by the Municipality of Brescia, which owns 25% of company shares.

FINANCIAL VIABILITY

The district heating system has been highly competitive to alternatives forms of heating, being cheaper than natural gas heating for all connected buildings. The group has been financially successful, having already paid back investments into the original system, while continuing to generate profits yearly. district heating consumers are subjected to specific tariffs depending on their use; rates are different for one-family houses, residential apartment buildings, and tertiary buildings.

CO-BENEFITS

The development of district heating systems in Brescia has allowed the town to integrate alternate fuel sources beyond fossil fuels, now including 40% of its heat supply from a waste-to-energy plant, a marked improvement from its 100% use of fossil fuels in the 1950s. The system is also going to allow more integration of surplus heat recovery from nearby industrial and waste-water facilities, and the integration of thermal storage systems. In its current state, the district heating system has also reduced heating prices for consumers that are connected to the grid.

Beyond energy efficiency and cost-effectiveness, the system has also created opportunities for innovation and growth. This includes projects exploring the use of smart grids – the Brescia Smart Living Project – aimed to integrate improved public services and governance.