TORONTO

EX18.15 Attachment 1

The "Preliminary Node Scan of Potential District Energy Implementation in the City of Toronto" has been revised as of September 4, 2012.

The revisions do not materially affect findings, conclusions or recommendations of this report.

PRELIMINARY NODE SCAN OF POTENTIAL DISTRICT ENERGY IMPLEMENTATION IN THE CITY OF TORONTO

(SUPPLEMENTARY MATERIAL)

Further to the receipt of the enclosed report entitled "Potential District Energy Implementation in the City of Toronto" by Genivar Consultants LP and dated October 1, 2010 staff of Facilities Management Division – Energy & Strategic Initiatives - Energy Efficiency Office (EEO) prepared the following addendums (attached) to further illustrate the potential District Energy (DE) Nodes screening criteria, as well as, location maps for the DE Nodes.

. **ADDENDUMS (attached)**

A) Location Map for 27 Potential District Energy Systems (DES) Nodes in the City of Toronto

B) Gross Floor Areas, estimated for each DE Node

C) DES Nodes Screening Matrix

D) Individual Maps of 27 Potential DES Nodes

In addition, EEO staff summarized the following overall conclusion of the Genivar report and outlined challenges and associated opportunities.

OVERALL CONCLUSION

There is significant potential for converting new challenges into opportunities in the City of Toronto with the implementation of District Energy Systems (DES) and Combined Heat & Power (CHP) with the benefit of fostering economic development, increasing energy conservation and resulting reductions in greenhouse gas emissions, as well as, achieving energy security. The City of Toronto's experience in DES is extensive - about 100 years – dating from TDHC (now Enwave Energy Corporation) through to the recent Toronto Community Housing Corporation (TCHC) Regent Park.

CHALLENGES and OPPORTUNITIES

The Challenges (from Section 2.1 of the Genivar report) include:

- Ever increasing electrical loads within Toronto (resulting primarily from population growth and increased connected loads per person) will continue to add strain to the existing transmission infrastructure into the City. Security of supply was most evident during the blackout of 2003.
- Ontario's fleet of coal-fired power plants will be phased out by 2014 and the existing fleet of nuclear power plants is approaching 40 years of age. Hence there is forecast shortage of electrical energy generation in the future.
- Recognition of increasing extreme weather events in the Province of Ontario which are linked to increased fossil fuel pollutants of exhaust.

Currently in Ontario, there is no policy which governs DES - unlike gas and electrical utilities which are regulated by the Ontario Energy Board (OEB).

CHALLENGES and OPPORTUNITIES (Cont'd)

Opportunities exist, associated with the above challenges, including:

- Significant economic development potential in Toronto from local solutions to increased energy conservation, and local clean energy generation. Approximately $4.5 billion is spent in Toronto on energy every year, much of which leaves the local Toronto economy because most generation occurs outside and is transmitted into the City.
- Potential new sources of revenue to the City from DES and CHP implementation, through innovative partnerships.
- Resulting reduction in greenhouse gas emissions from energy conservation and local clean energy generation.

Further to the Ontario Power Authority (OPA) Feed-in-Tariff (FIT) program, which currently has incentives and policy for renewable energy (which includes biomass and biogas CHP projects), the OPA will be launching in Q2 2011 a Clean Energy Standard Offer Program (CESOP). The CESOP program is expected to offer an appropriate long-term guaranteed power purchase agreement for CHP projects under 20 MWe.

Addendums

Preliminary Node Scan of Potential District Energy Implementation in the City of Toronto Report

A: Map of 27 Potential DES Nodes

Large City of Toronto map identifying the potential node locations

B: Estimation of GFA Served by 27 Potential DES Nodes

Table estimating the potential gross floor area that would be served by the 27 DES Nodes

C: Sample Level 1 Screening Matrix for DES Nodes

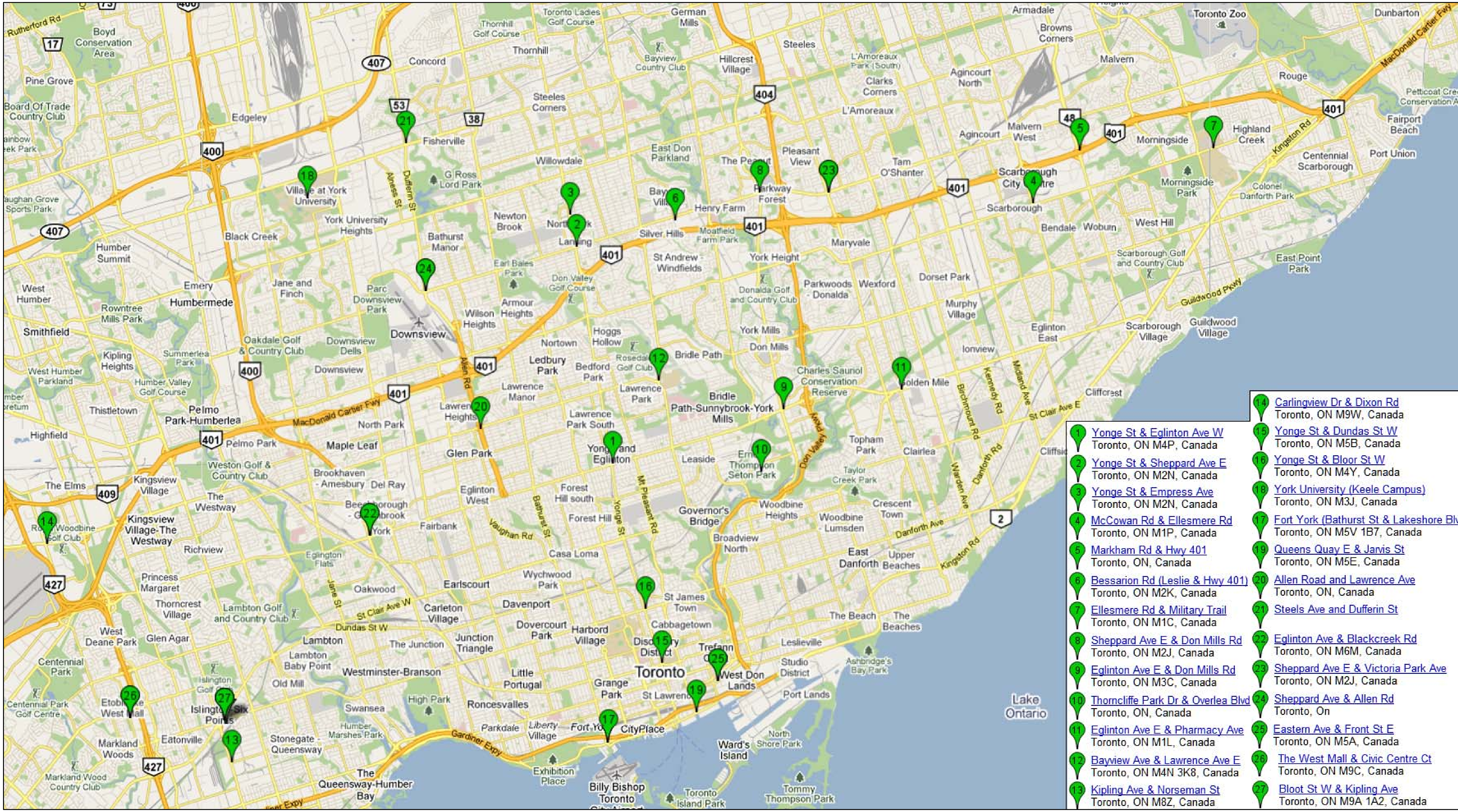
Sample Screening Matrix and results for identifying best DES node locations

D: Individual Maps of 27 Potential DES Nodes

Individual maps of potential DES node locations to show service radius

REF # EEO-DES-101001-A317 Date: March 17, 2011

Addendum A: District Energy Program Scan Potential Node Locations



TORONTO Energy Efficiency Office

Addendum B: District Energy Scan GFA Estimation for potential node sites

Site	Intersection	Measured Area (dia. km)	Gross Floor Area m^2 Commercial / Institutional	Gross Floor Area m^2 Multi-Residential	Gross Floor Area m^2 Total
1	Yonge St & Eglinton Ave	1.0	600,000.00	700,000.00	1,300,000.00
2	Yonge St & Sheppard Ave	1.0	500,000.00	100,000.00	600,000.00
3	Yonge St & Empress Ave	1.0	300,000.00	300,000.00	600,000.00
4	McCowan Rd & Ellesmere Rd	1.5	700,000.00	200,000.00	900,000.00
5	Markham Rd & Hwy 401	1.5	100,000.00	100,000.00	200,000.00
6	Bessarion Rd (Leslie & Hwy 401)	1.0	700,000.00	300,000.00	1,000,000.00
7	Ellesmere Rd & Military Trail	1.5	400,000.00	100,000.00	500,000.00
8	Sheppard Ave & Don Mills Rd	1.0	500,000.00	100,000.00	600,000.00
9	Eglinton Ave & Don Mills Rd	1.5	700,000.00	100,000.00	800,000.00
10	Thorncliffe Park (Overlea Blvd & Thorncliffe Park Dr)	1.5	200,000.00	700,000.00	900,000.00
11	Eglinton Ave & Pharmacy Ave	1.5	400,000.00	100,000.00	500,000.00
12	Bayview Ave & Lawrence Ave	1.5	900,000.00	50,000.00	950,000.00
13	Kipling Ave & Norseman St	1.5	1,300,000.00	10,000.00	1,310,000.00
14	Carlingview Dr & Dixon Rd	1.5	400,000.00	200,000.00	600,000.00
15	Yonge St & Dundas St	1.0	700,000.00	200,000.00	900,000.00
16	Yonge St & Bloor St	1.0	700,000.00	100,000.00	800,000.00
17	Fork York (Bathurst St & Lakeshore Blvd)	1.5	2,400,000.00	350,000.00	2,750,000.00
18	York University Keele Campus	1.5	450,000.00	100,000.00	550,000.00
19	East Bay Front (Jarvis St & Queens Quay)*	1.0	287,000.00	630,000.00	917,000.00
20	Lawrence Allen Phase 2 (Allen Rd and Lawrence Ave)*	1.5	83,000.00	600,000.00	683,000.00
21	Steels Ave and Dufferin St	1.5	450,000.00	75,000.00	525,000.00
22	Eglinton Ave & Blackcreek Rd	1.5	400,000.00	250,000.00	650,000.00
23	Sheppard Ave & Victoria Park Ave	1.5	300,000.00	400,000.00	700,000.00
24	Downsview Corporate Centre (Sheppard Ave & Allen Rd)*	1.0	195,000.00	240,000.00	435,000.00
25	West Don Lands (Eastern Ave & Front St)*	1.0	90,000.00	430,000.00	520,000.00
26	Etobicoke Civic Complex (West mall & Civic Centre Court)*	0.5	38,000.00	282,000.00	320,000.00
27	Westwood Theatre Lands (Bloor St W & Kipling Ave)*	1.0	100,000.00	180,000.00	280,000.00
		Total	**13,893,000.00**	**6,897,000.00**	**20,790,000.00**

**** New Development***

Addendum C: Sample Level 1 Screening Matrix For District Energy Nodes

Potential DES Node Locations	Maximum Score	1: Yonge St & Eglinton Ave	2: Yonge St & Sheppard Ave	3: Yonge St & Empress Ave	4: McCowan Rd & Ellesmere Rd	5: Markham Rd & Hwy 401	6: Bessarion Rd (Leslie & Hwy 401)	7: Ellesmere Rd & Military Trail
Diameter of node development (km)		1	1	1	1.5	1.5	1	1.5
Area of node (m^2)						1,766,250		
Commercial / Institutional Component								
Gross Floor Area (x100,000 m^2)		6.00	5.00	3.00	7.00	1.00	7.00	4.00
RANK		785,000 8	785,000 9	785,000 18	3	23	3	13
% of total Node Development		46%	83%	50%	1,766,250 78%	50%	70%	1,766,250 80%
Developed density (floor area (m^2) / node area (m^2))		0.764	0.637	0.382	0.396	0.057	785,000 0.892	0.226
RANK		4	6	12	10	26	1	17
Multi-Residential Component								
Gross Floor Area (x100,000 m^2)		7.00	1.00	3.00	2.00	1.00	3.00	1.00
RANK		1	17	7	13	17	7	17
% of total Node Development		54%	17%	50%	22%	50%	30%	20%
Developed density (floor area (m^2) / node area (m^2))		0.892	0.127	0.382	0.113	0.057	0.382	0.057
RANK		2	15	6	18	20	6	20
Total Node Development								
Gross Floor Area (x100,000 m^2)		13.00	6.00	6.00	9.00	2.00	10.00	5.00
Developed density (floor area (m^2) / node area (m^2))		1.656	0.764	0.764	0.510	0.113	1.274	0.283
RANK		1	8	8	15	27	3	25
Score	**10**	**10**	**8**	**8**	**6**	**2**	**10**	**2**
Node Status (Maximum Score = 10)								
New vs. Existing Development		existing	existing	existing	existing	existing	existing	existing
Score	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Contains known existing CHP								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Proximity to Existing DES								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Proximity to Other Considered DES Node			near 3	near 2	near 5	near 4		
Score	**5**	**0**	**5**	**5**	**5**	**5**	**0**	**0**
Electrical Load Considerations								
Suitable for CESOP CHP								
Score	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Proximity to Deep Lake Cooling								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Within Downtown Core								
Score	**5**	**5**	**0**	**0**	**0**	**0**	**0**	**0**
Thermal Load Considerations								
Contains Institutional								
Score	**5**	**0**	**5**	**5**	**0**	**0**	**5**	**5**
Contains Light Industrial								
Score	**3**	**0**	**0**	**0**	**3**	**0**	**0**	**0**
Contains Heavy Industrial								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Renewable Energy Considerations								
Near Municipal Wastewater - biogas								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Scoring Summary								
Total Score	**68**	**20**	**23**	**23**	**19**	**12**	**20**	**12**
RANK		**15**	**11**	**11**	**17**	**24**	**15**	**24**

Addendum C: Sample Level 1 Screening Matrix For District Energy Nodes

Potential DES Node Locations	**Maximum Score**	**8: Sheppard Ave E & Don Mills Rd**	**9: Eglinton Ave E & Don Mills Rd**	**10: Thorncliffe Park (Overlea Blvd)**	**11: Eglinton Ave & Pharmacy Ave**	**12: Bayview Ave & Lawrence Ave E**	**13: Kipling Ave & Norseman St**	**14: Carlingview Dr & Dixon Rd**
Diameter of node development (km)		1	1.5	1.5	1.5	1.5	1.5	1.5
Area of node (m^2)								
Commercial / Institutional Component								
Gross Floor Area (x100,000 m^2)		5.00	7.00	2.00	4.00	1,766,250 9.00	13.00	4.00
RANK		785,000 9	3	1,766,250 21	13	2	1	13
% of total Node Development		83%	88%	22%	80%	95%	1,766,250 99%	67%
Developed density (floor area (m^2) / node area (m^2))		0.637	1,766,250 0.396	0.113	1,766,250 0.226	0.510	0.736	1,766,250 0.226
RANK		6	10	25	17	8	5	17
Multi-Residential Component								
Gross Floor Area (x100,000 m^2)		1.00	1.00	7.00	1.00	0.50	0.10	2.00
RANK		17	17	1	17	26	27	13
% of total Node Development		17%	13%	78%	20%	5%	1%	33%
Developed density (floor area (m^2) / node area (m^2))		0.127	0.057	0.396	0.057	0.028	0.006	0.113
RANK		15	20	5	20	26	27	18
Total Node Development								
Gross Floor Area (x100,000 m^2)		6.00	8.00	9.00	5.00	9.50	13.10	6.00
Developed density (floor area (m^2) / node area (m^2))		0.764	0.453	0.510	0.283	0.538	0.742	0.340
RANK		8	17	15	25	14	11	22
Score	**10**	**8**	**4**	**6**	**2**	**6**	**6**	**2**
Node Status (Maximum Score = 10)								
New vs. Existing Development		existing	existing	existing	existing	existing	existing	existing
Score	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Contains known existing CHP								GTAA
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
Proximity to Existing DES								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Proximity to Other Considered DES Node		near 23	near 10	near 9			near 27	
Score	**5**	**5**	**5**	**5**	**0**	**0**	**5**	**0**
Electrical Load Considerations								
Suitable for CESOP CHP								
Score	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Proximity to Deep Lake Cooling								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Within Downtown Core								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Thermal Load Considerations								
Contains Institutional								
Score	**5**	**0**	**5**	**0**	**0**	**5**	**0**	**5**
Contains Light Industrial								
Score	**3**	**0**	**0**	**0**	**0**	**0**	**3**	**0**
Contains Heavy Industrial								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**5**	**5**
Renewable Energy Considerations								
Near Municipal Wastewater - biogas								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Scoring Summary								
Total Score	**68**	**18**	**19**	**16**	**7**	**16**	**24**	**22**
RANK		**19**	**17**	**20**	**27**	**20**	**9**	**13**

Addendum C:

Sample Level 1 Screening Matrix For District Energy Nodes

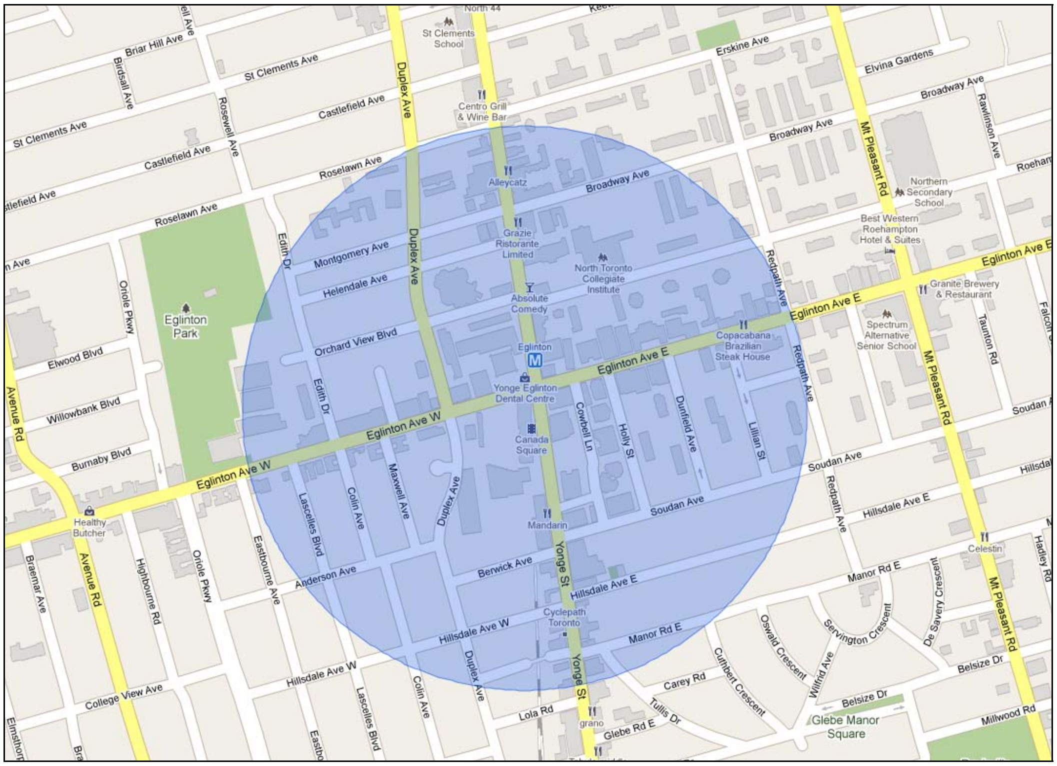
Potential DES Node Locations	**Maximum Score**	**15: Yonge St & Dundas St**	**16: Yonge St & Bloor St**	**17: Fort York (Bathurst St & Lakeshore Blvd)**	**18: York University (Keele Campus)**	**19: EAST BAY FRONT (Jarvis St & Queens Quay)**	**20: LAWRENCE PHASE 2 (Allen Rd and Lawrence Ave)**	**21: Steeles Ave and Dufferin St**
Diameter of node development (km)		1	1	1	1.5	1	1.5	1.5
Area of node (m^2)								
Commercial / Institutional Component								
Gross Floor Area (x100,000 m^2)		7.00	7.00	4.00	4.50	2.87	0.83	4.50
RANK		3	3	13	11	20	26	1,766,250 11
% of total Node Development		785,000 78%	785,000 88%	785,000 62%	82%	785,000 31%	12%	86%
Developed density (floor area (m^2) / node area (m^2))		0.892	0.892	0.510	1,766,250 0.255	0.366	1,766,250 0.047	0.255
RANK		1	1	8	14	13	27	14
Multi-Residential Component								
Gross Floor Area (x100,000 m^2)		2.00	1.00	2.50	1.00	6.30	6.00	0.75
RANK		13	17	10	17	3	4	25
% of total Node Development		22%	13%	38%	18%	69%	88%	14%
Developed density (floor area (m^2) / node area (m^2))		0.255	0.127	0.318	0.057	0.803	0.340	0.042
RANK		11	15	9	20	3	8	25
Total Node Development								
Gross Floor Area (x100,000 m^2)		9.00	8.00	6.50	5.50	9.17	6.83	5.25
Developed density (floor area (m^2) / node area (m^2))		1.146	1.019	0.828	0.311	1.168	0.387	0.297
RANK		5	6	7	23	4	19	24
Score	**10**	**10**	**8**	**8**	**2**	**10**	**4**	**2**
Node Status (Maximum Score = 10)								
New vs. Existing Development		existing	existing	existing	existing	new	new	existing
Score	**10**	**0**	**0**	**0**	**0**	**10**	**10**	**0**
Contains known existing CHP		U of T	U of T					Sanofi
Score	**5**	**5**	**5**	**0**	**0**	**0**	**0**	**5**
Proximity to Existing DES		ENWAVE	U of T	ENWAVE		ENWAVE/ WTFT		
Score	**5**	**5**	**5**	**5**	**0**	**5**	**0**	**0**
Proximity to Other Considered DES Node								
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Electrical Load Considerations								
Suitable for CESOP CHP								
Score	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Proximity to Deep Lake Cooling								
Score	**5**	**5**	**5**	**5**	**0**	**5**	**0**	**0**
Within Downtown Core								
Score	**5**	**5**	**5**	**5**	**0**	**5**	**0**	**0**
Thermal Load Considerations								
Contains Institutional								
Score	**5**	**5**	**5**	**0**	**5**	**0**	**5**	**5**
Contains Light Industrial								
Score	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Contains Heavy Industrial								
Score	**5**	**0**	**0**	**0**	**0**	**5**	**0**	**5**
Renewable Energy Considerations								
Near Municipal Wastewater - biogas								
Score	**5**	**0**	**0**	**0**	**0**	**5**	**0**	**0**
Scoring Summary								
Total Score	**68**	**40**	**38**	**28**	**12**	**50**	**24**	**22**
RANK		**2**	**3**	**7**	**24**	**1**	**9**	**13**

Addendum C: Sample Level 1 Screening Matrix For District Energy Nodes

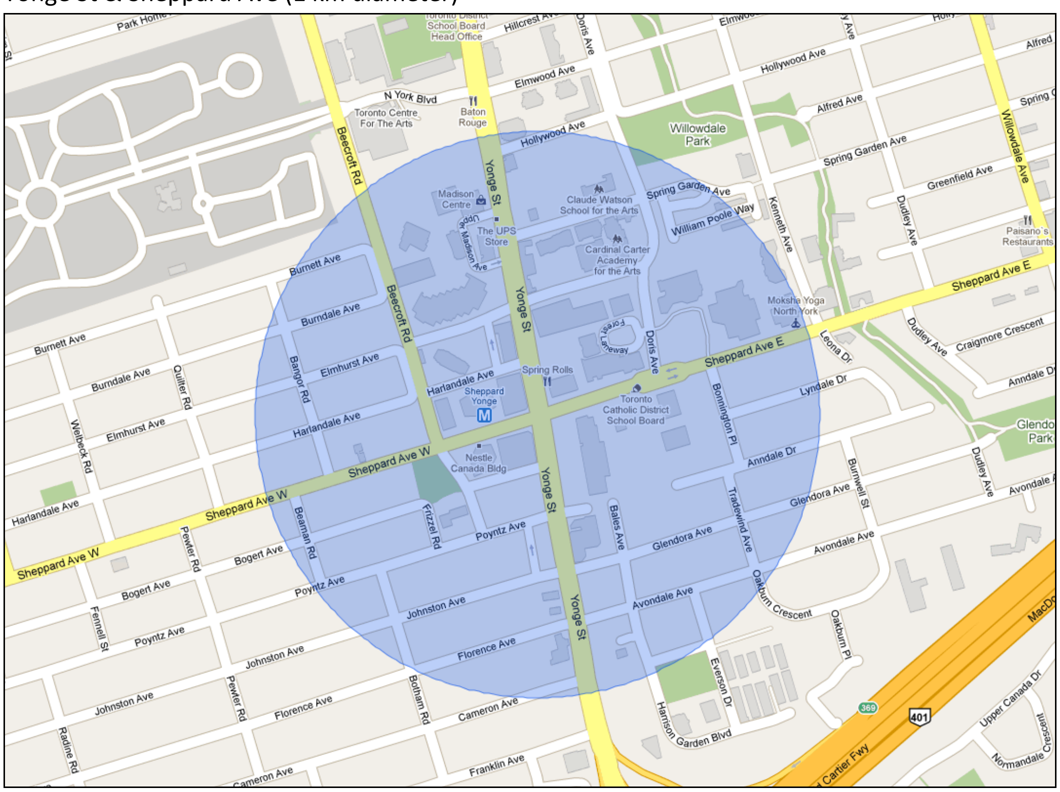
Potential DES Node Locations	**Maximum Score**	**22: Eglinton Ave & Blackcreek Rd**	**23: Sheppard Ave & Victoria Park Ave**	**24: DOWNSVIEW CORPORATE CENTRE (Sheppard Ave & Allen Rd)**	**25: WEST DON LANDS (Eastern Ave & Front St)**	**26: Etobicoke Civic Complex (West Mall & Civic Centre Court)**	**27: Westwood Theatre Lands (Bloor St. W & Kipling Ave.)**
Diameter of node development (km)		1.5	1.5	1	1	0.5	1
Area of node (m^2)					785,000		
Commercial / Institutional Component							
Gross Floor Area (x100,000 m^2)		4.00	3.00	1.95	0.90	0.38	1.00
RANK		13	18	22	25	27	23
% of total Node Development		62%	43%	45%	17%	12%	785,000 36%
Developed density (floor area (m^2) / node area (m^2))		1,766,250 0.226	1,766,250 0.170	785,000 0.248	0.115	196,250 0.194	0.127
RANK		17	22	16	24	21	23
Multi-Residential Component							
Gross Floor Area (x100,000 m^2)		2.50	4.00	2.40	4.30	2.82	1.80
RANK		10	6	12	5	9	16
% of total Node Development		38%	57%	55%	83%	88%	64%
Developed density (floor area (m^2) / node area (m^2))		0.142	0.226	0.306	0.548	1.437	0.229
RANK		14	13	10	4	1	12
Total Node Development							
Gross Floor Area (x100,000 m^2)		6.50	7.00	4.35	5.20	3.20	2.80
Developed density (floor area (m^2) / node area (m^2))		0.368	0.396	0.554	0.662	1.631	0.357
RANK		20	18	13	12	2	21
Score	**10**	**4**	**4**	**6**	**6**	**10**	**2**
Node Status (Maximum Score = 10)							
New vs. Existing Development		existing	existing	new	new	new	new
Score	**10**	**0**	**0**	**10**	**10**	**10**	**10**
Contains known existing CHP		former KODAK					
Score	**5**	**5**	**0**	**0**	**0**	**0**	**0**
Proximity to Existing DES					ENWAVE/ WTFT		
Score	**5**	**0**	**0**	**0**	**5**	**0**	**0**
Proximity to Other Considered DES Node			near 8				near 13
Score	**5**	**0**	**5**	**0**	**0**	**0**	**5**
Electrical Load Considerations							
Suitable for CESOP CHP							
Score	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Proximity to Deep Lake Cooling							
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**
Within Downtown Core							
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**
Thermal Load Considerations							
Contains Institutional							
Score	**5**	**0**	**0**	**5**	**5**	**0**	**0**
Contains Light Industrial							
Score	**3**	**0**	**0**	**0**	**0**	**0**	**3**
Contains Heavy Industrial							
Score	**5**	**0**	**0**	**5**	**0**	**0**	**5**
Renewable Energy Considerations							
Near Municipal Wastewater - biogas							
Score	**5**	**0**	**0**	**0**	**5**	**0**	**0**
Scoring Summary							
Total Score	**68**	**14**	**14**	**31**	**36**	**25**	**30**
RANK		**22**	**22**	**5**	**4**	**8**	**6**

Addendum D: Individual Maps of 27 Potential DES Nodes

1. Yonge St & Eglinton Ave (1 km diameter)

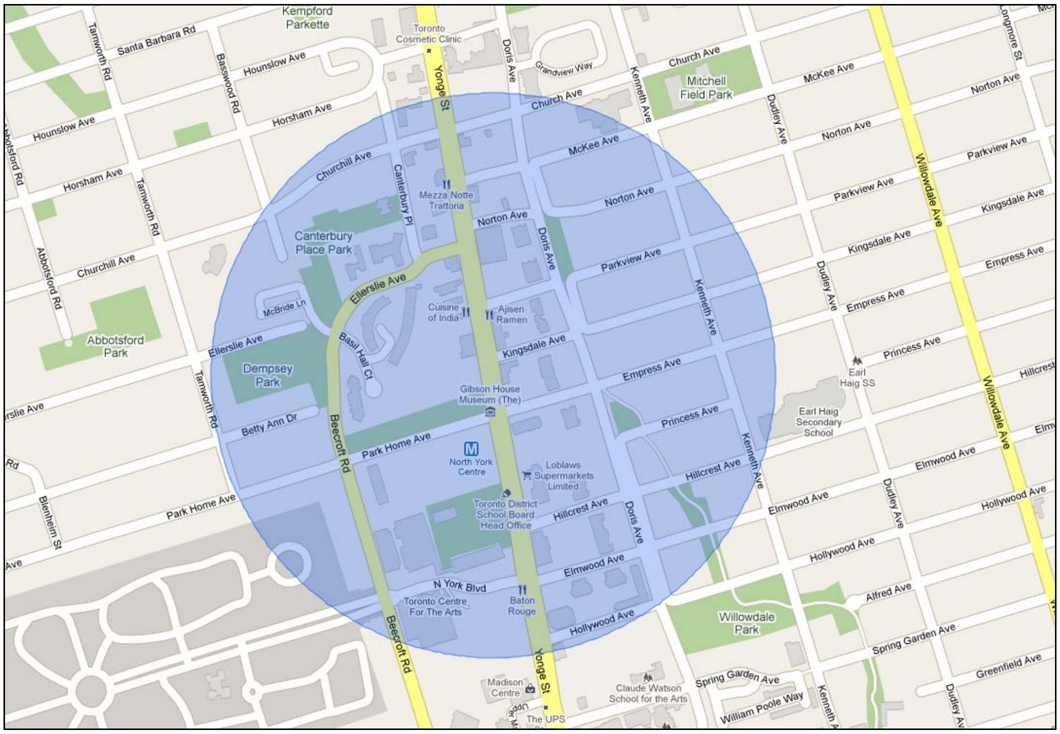


2. Yonge St & Sheppard Ave (1 km diameter)



Addendum D: Individual Maps of 27 Potential DES Nodes

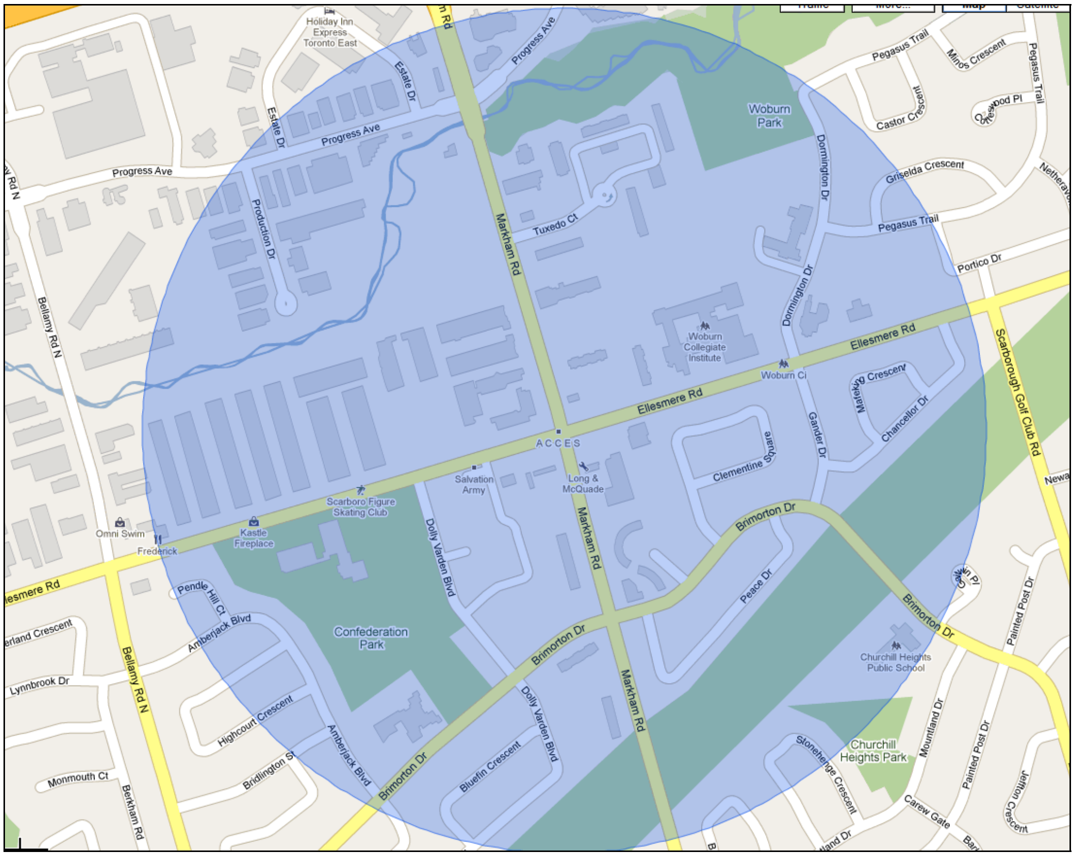
3. Yonge St & Empress Ave (1 km diameter)



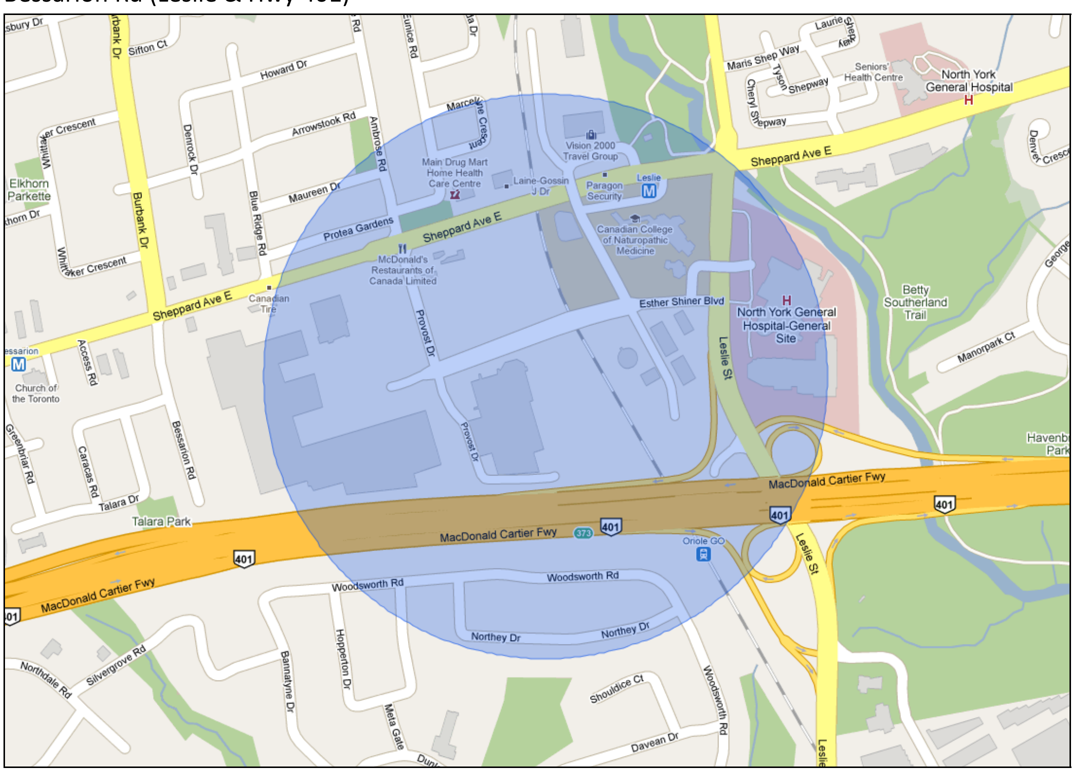
4. McCowan Rd & Ellesmere Rd (1.5 km diameter)

Addendum D: Individual Maps of 27 Potential DES Nodes

5. Markham Rd & Hwy 401 (1.5 km diameter)

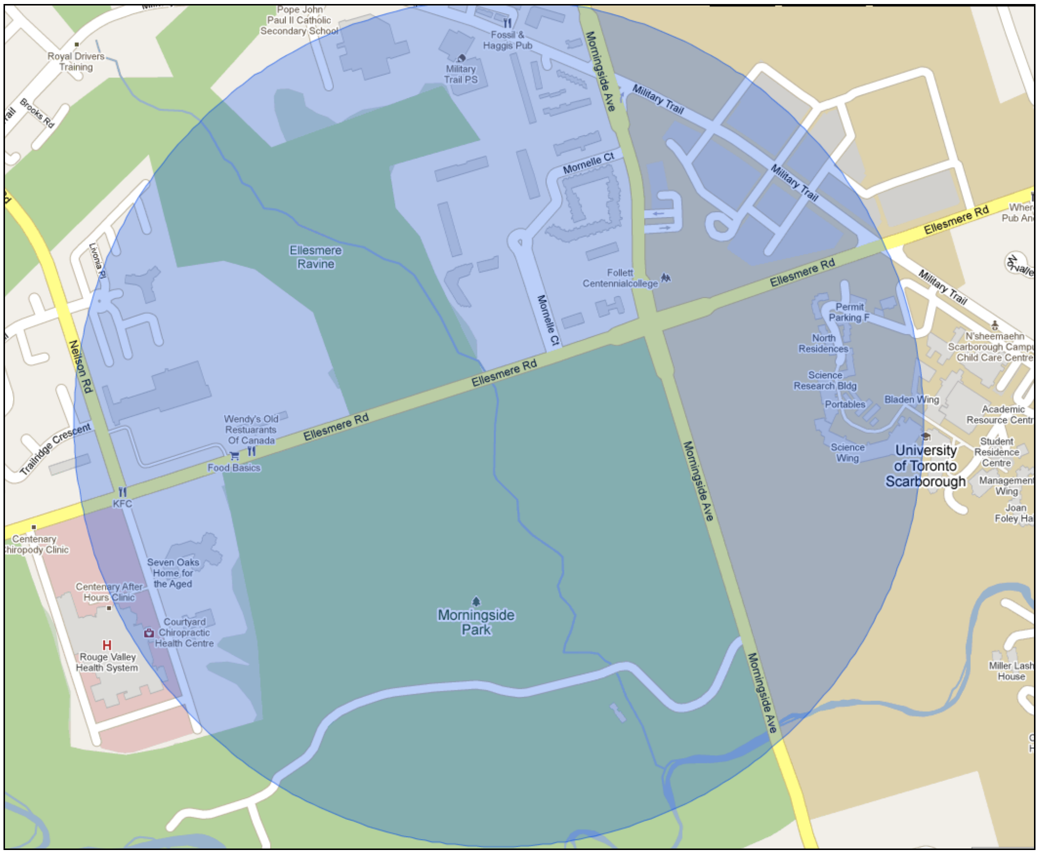


6. Bessarion Rd (Leslie & Hwy 401)

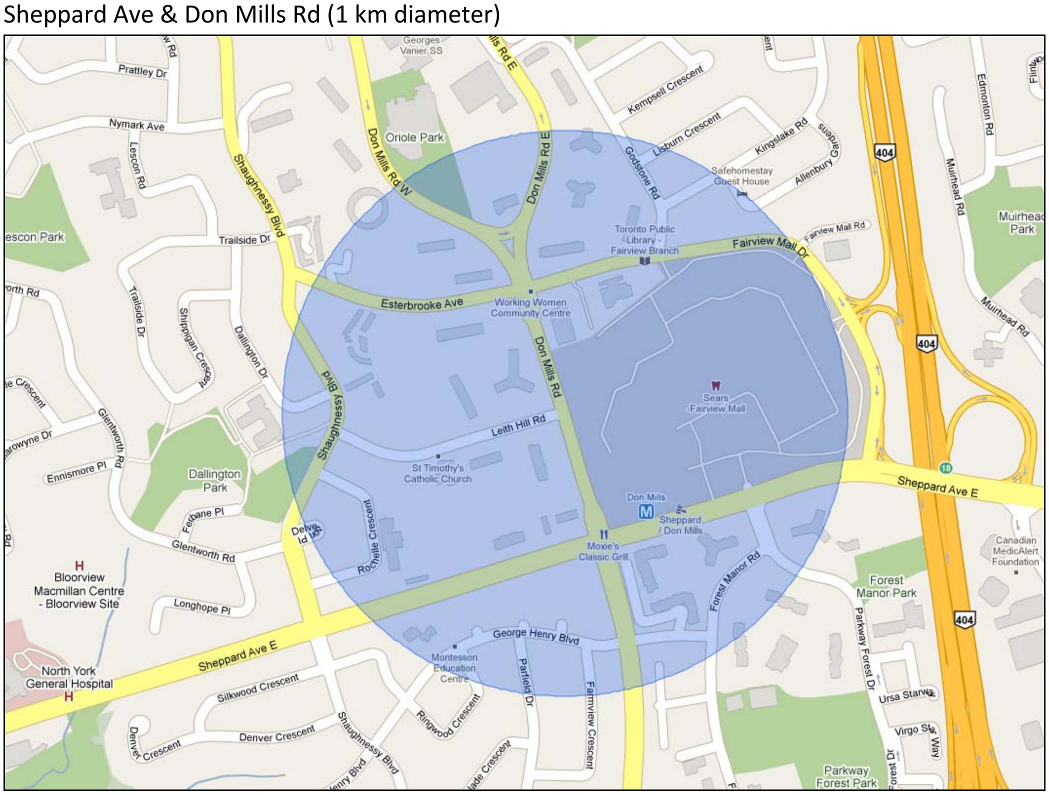


Addendum D: Individual Maps of 27 Potential DES Nodes

7. Ellesmere Rd & Military Trail (1.5 km diameter)

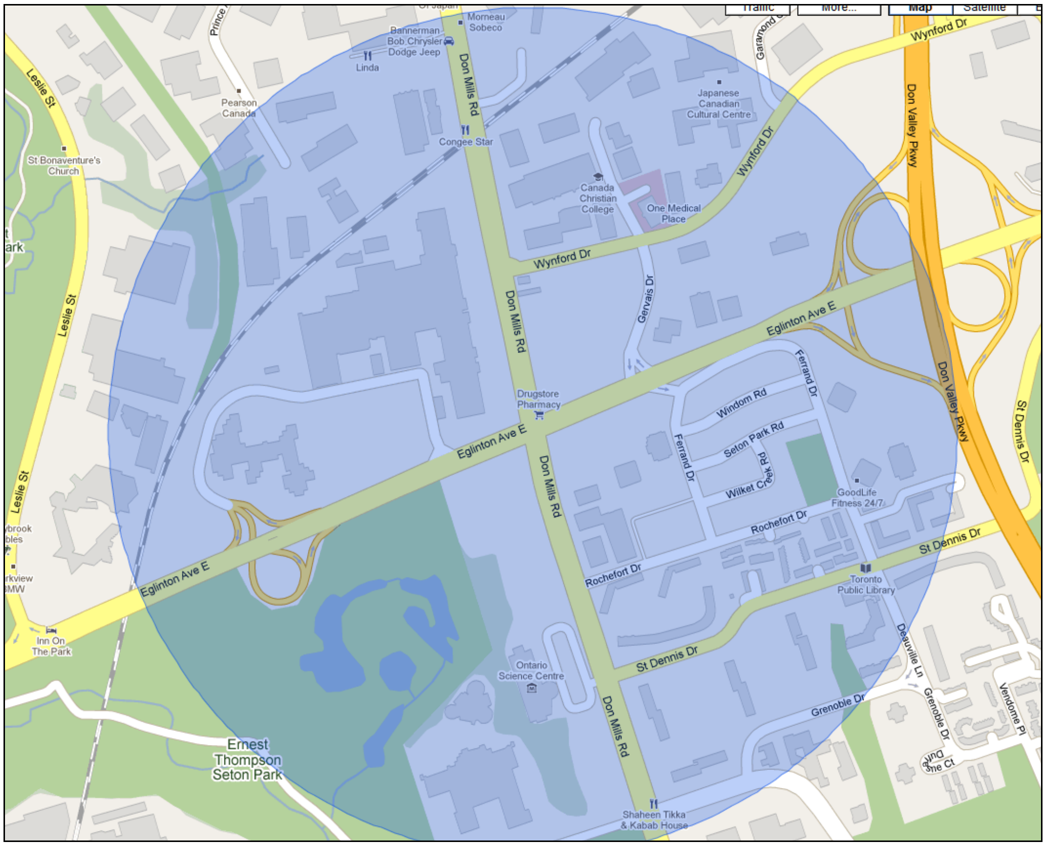


8. Sheppard Ave & Don Mills Rd (1 km diameter)

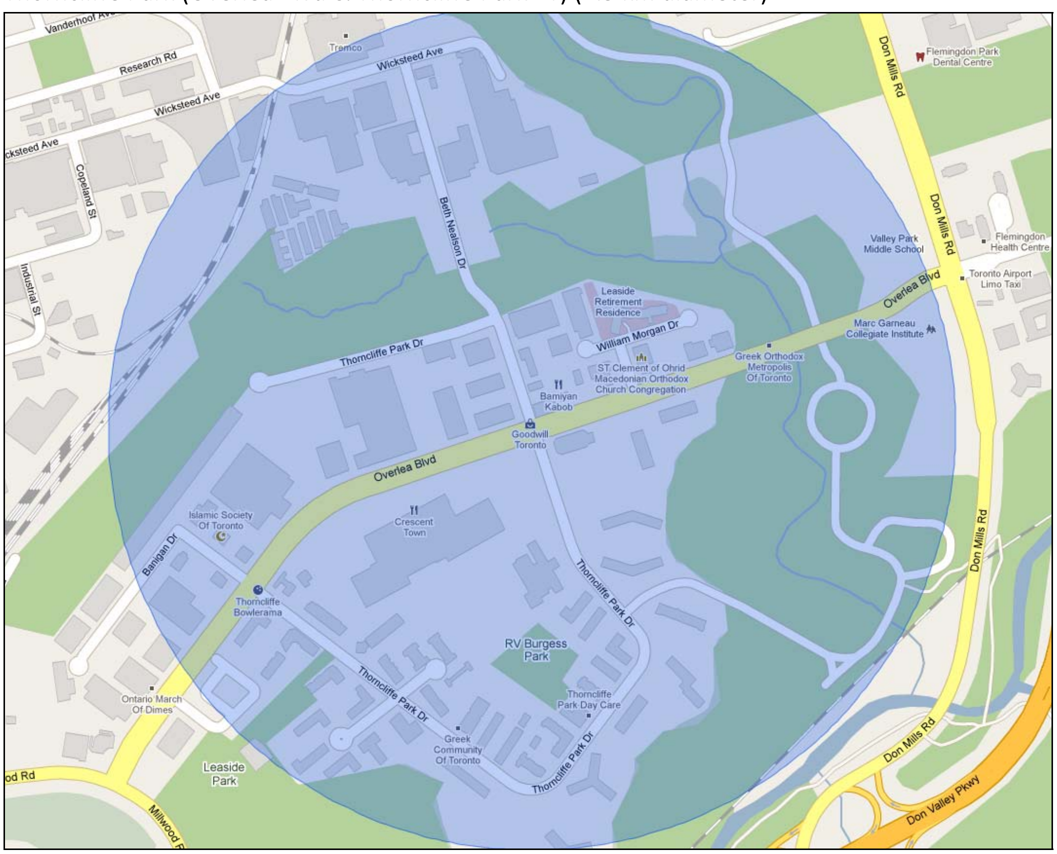


Addendum D: Individual Maps of 27 Potential DES Nodes

9. Eglinton Ave & Don Mills Rd (1.5 km diameter)



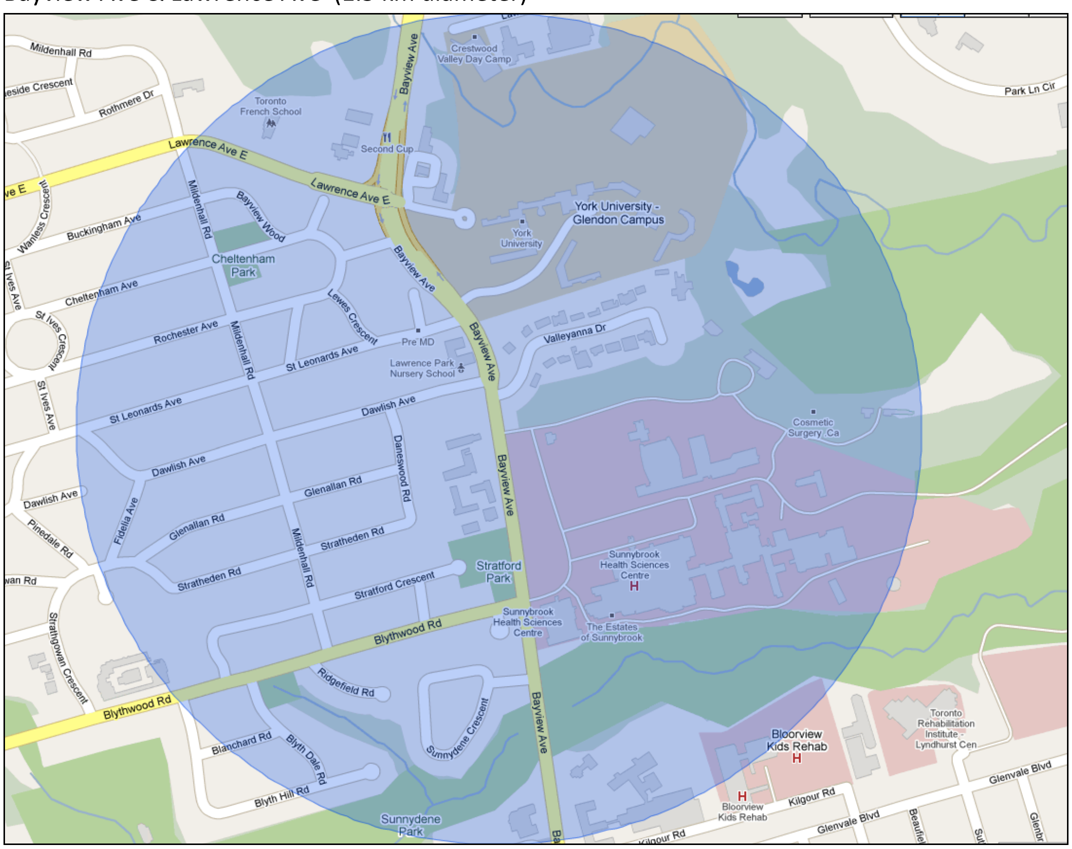
10. Thorncliffe Park (Overlea Blvd & Thorncliffe Park Dr) (1.5 km diameter)



Addendum D: Individual Maps of 27 Potential DES Nodes

11. Eglinton Ave & Pharmacy Ave (1.5 km diameter)

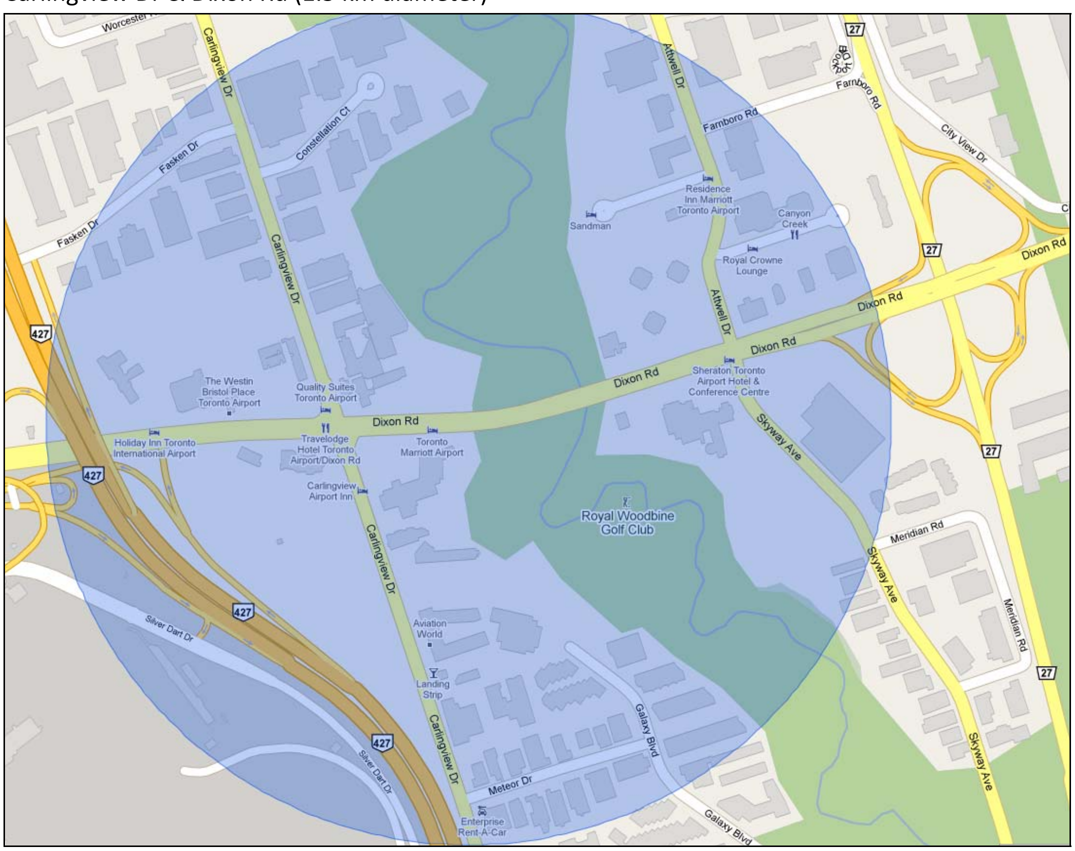
12. Bayview Ave & Lawrence Ave (1.5 km diameter)



Addendum D: Individual Maps of 27 Potential DES Nodes

13. Kipling Ave & Norseman St (1.5 km diameter)

14. Carlingview Dr & Dixon Rd (1.5 km diameter)



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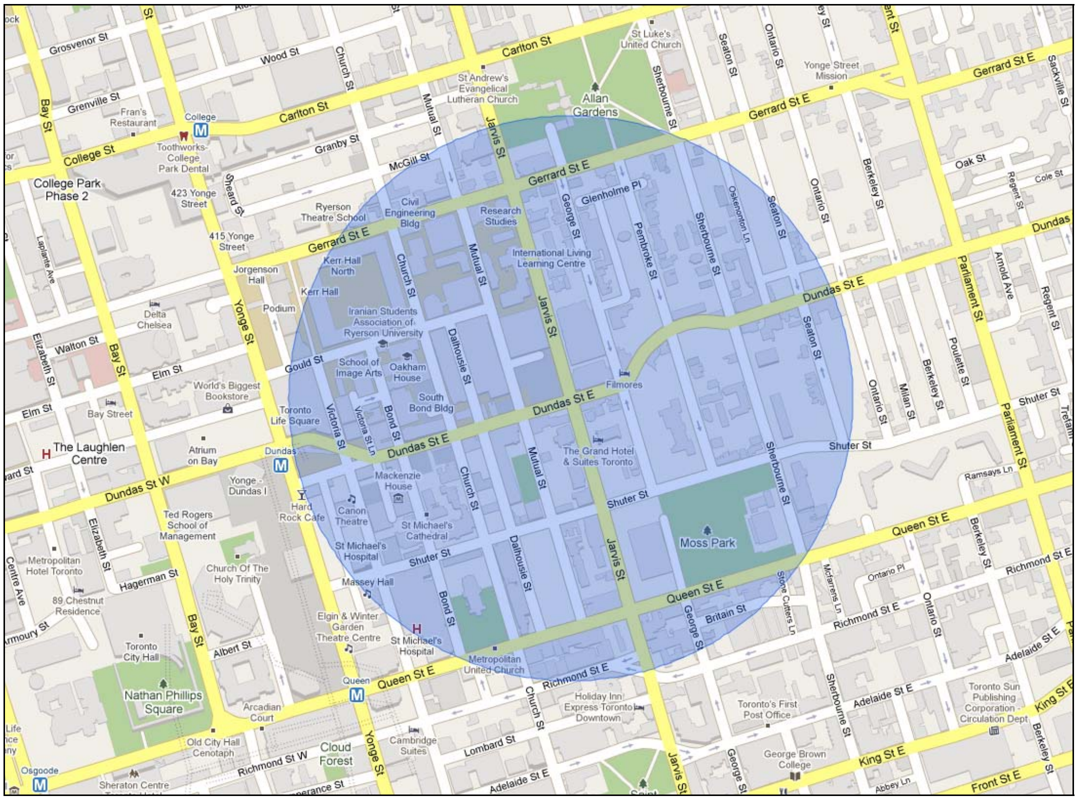
15. Yonge St & Dundas St (1 km diameter)



16. Yonge St & Bloor St (1 km diameter)

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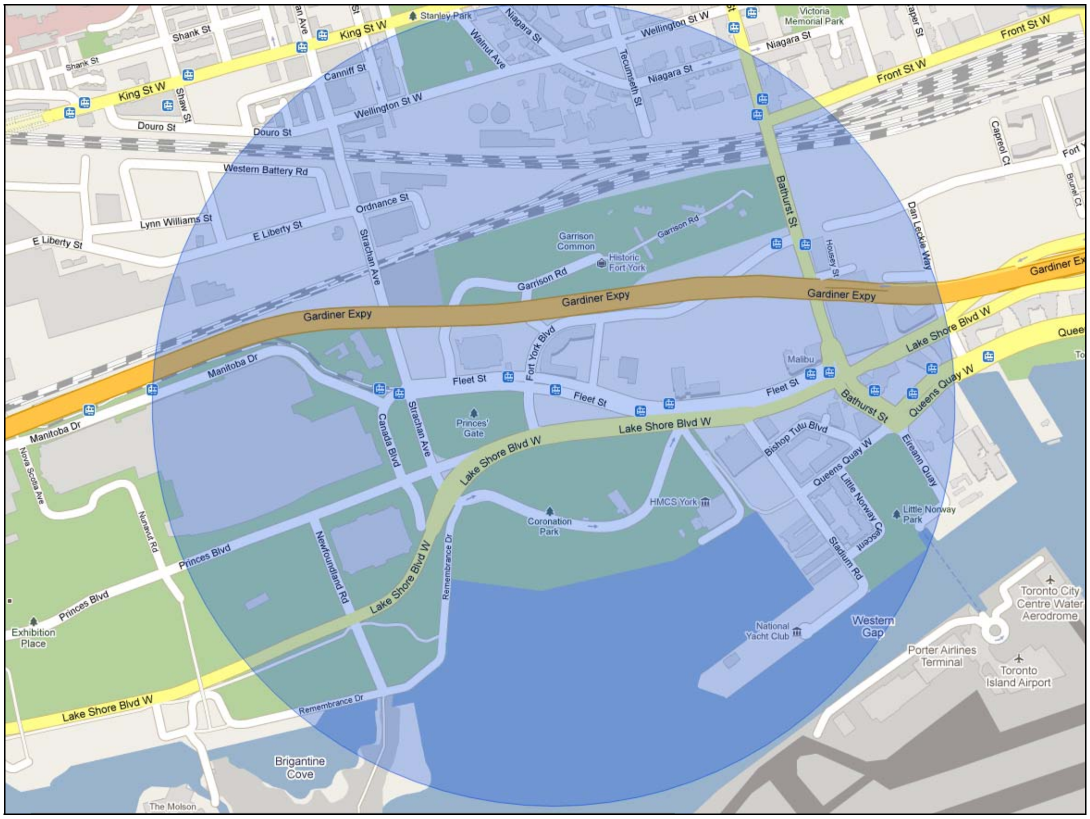
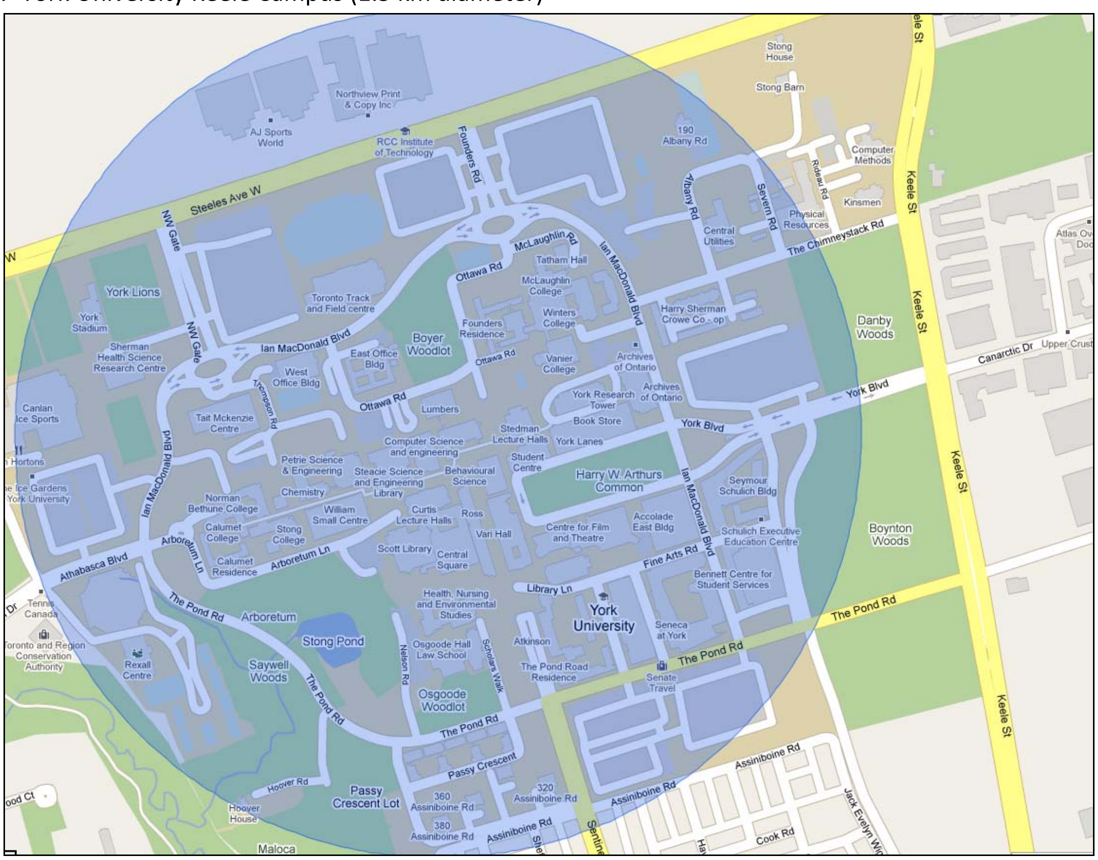
17. Fort York (Bathurst St & Lakeshore Blvd) (1.5 km diameter)

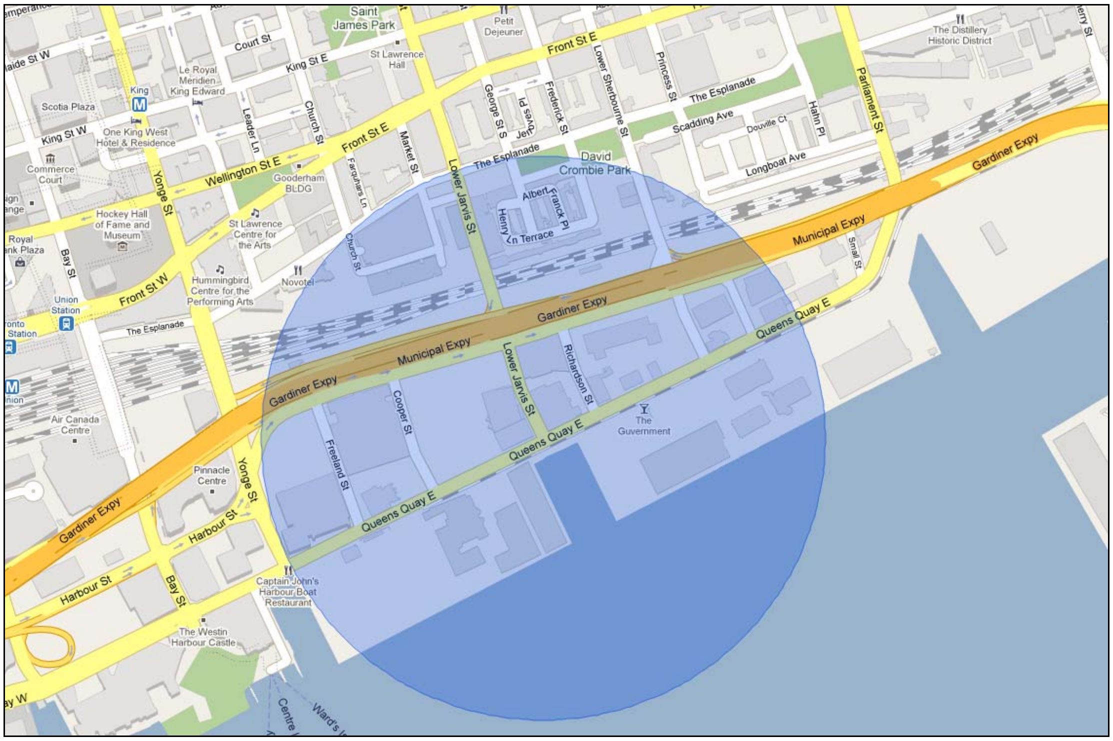


18. York University Keele Campus (1.5 km diameter)

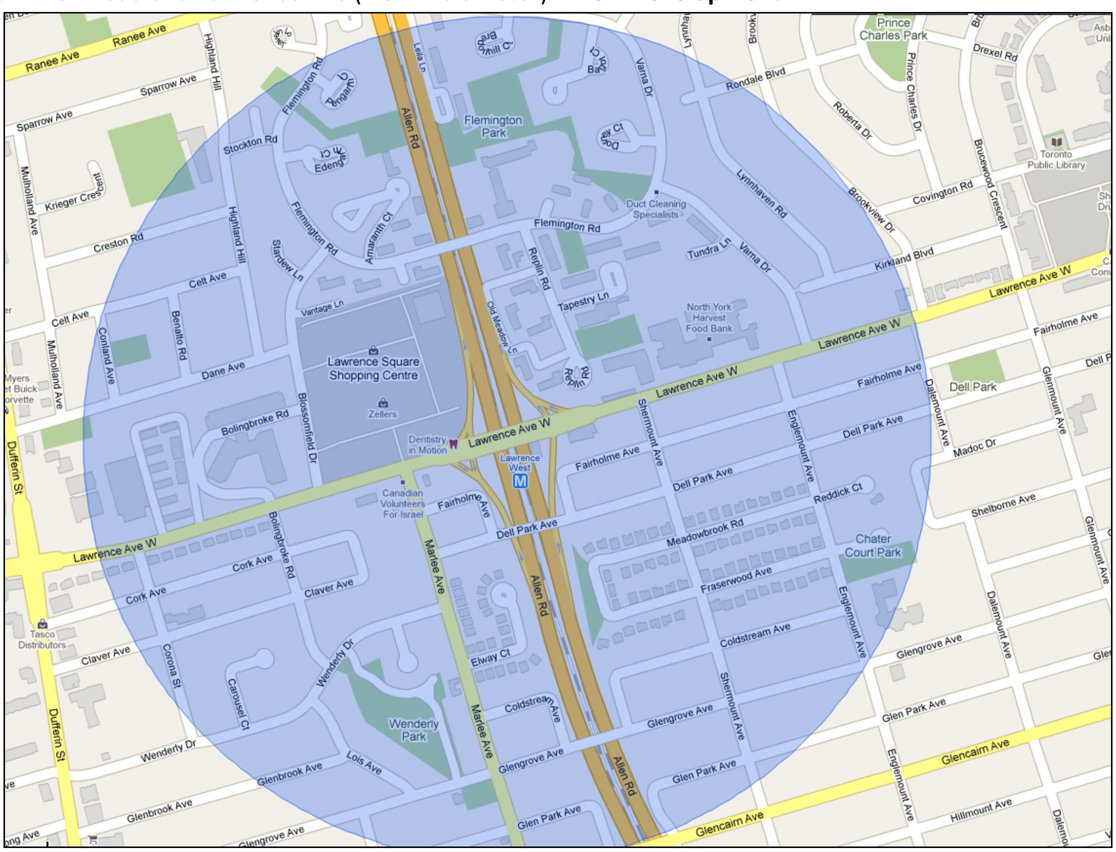


Addendum D: Individual Maps of 27 Potential DES Nodes

19. Jarvis St and Queens Quay (1 km diameter) – **New Development**



20. Allen Road and Lawrence Ave (1.5 km diameter) – **New Development**



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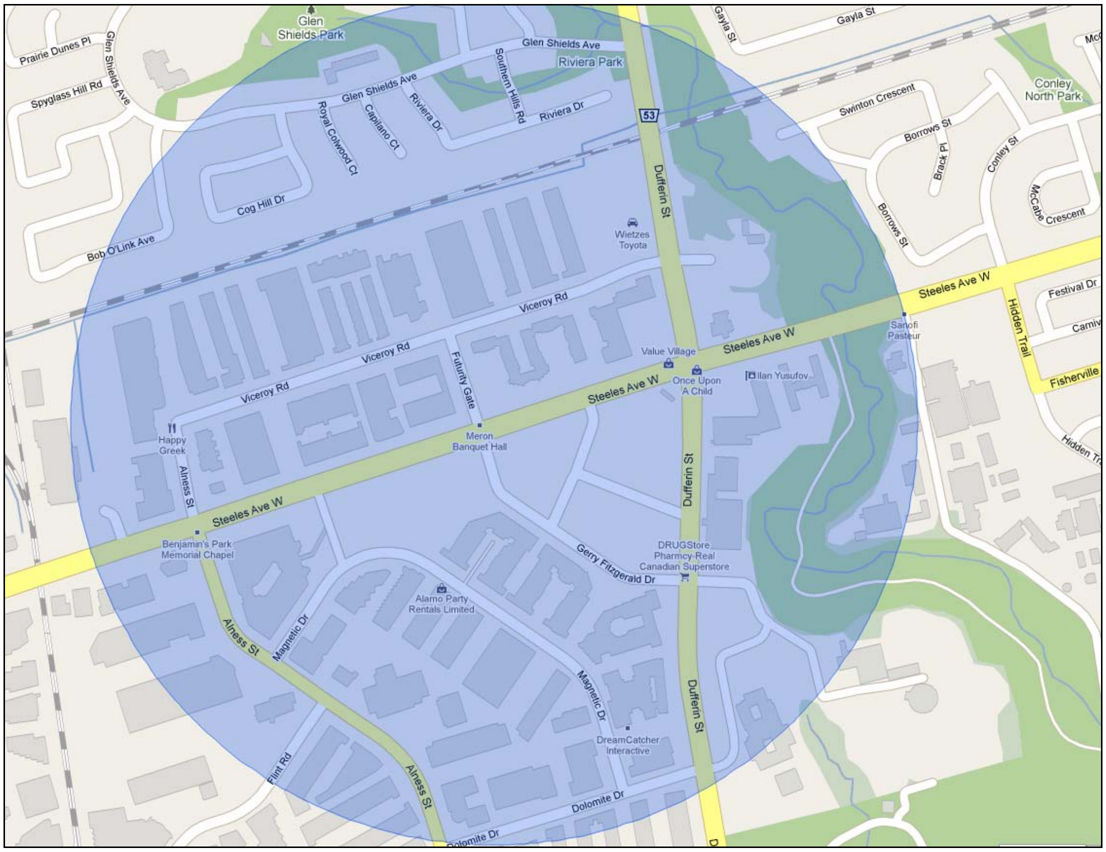
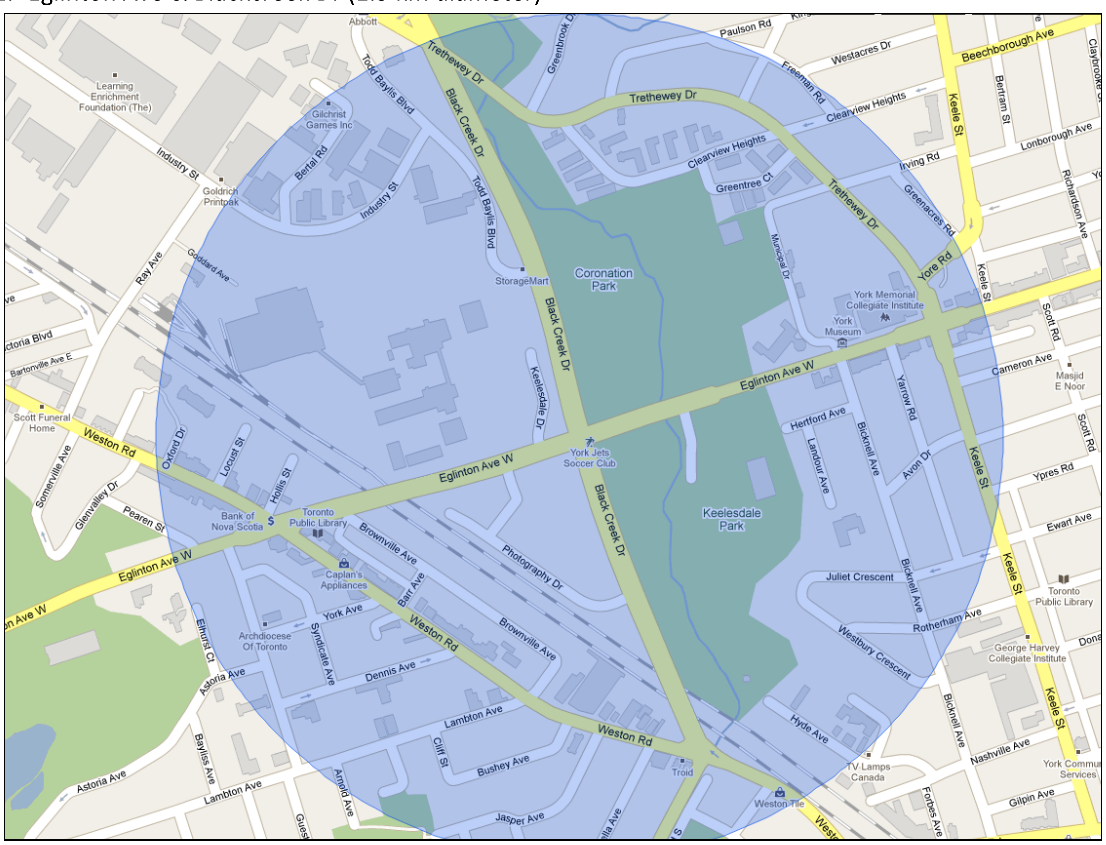
21. Steels Ave and Dufferin St (1.5 km diameter)



22. Eglinton Ave & Blackcreek Dr (1.5 km diameter)



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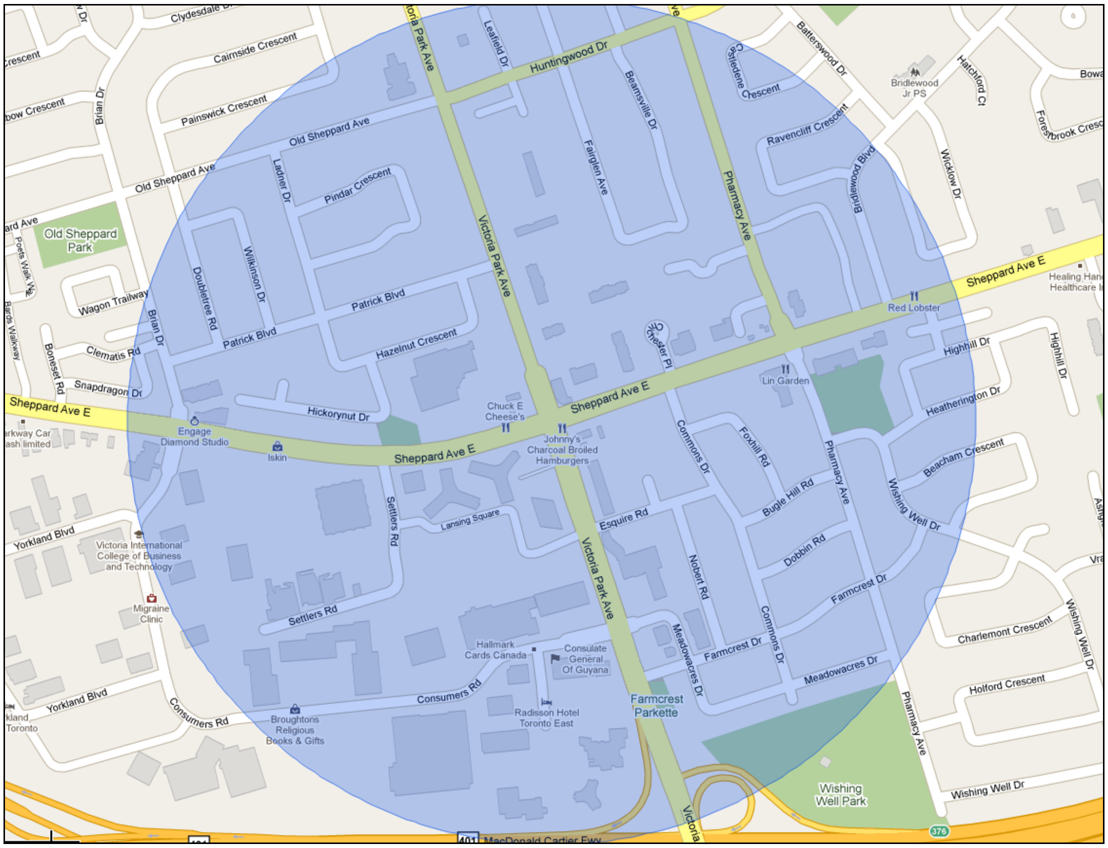
23. Sheppard Ave and Victoria Park Rd



24. Sheppard Ave & Allen Rd (1 km diameter) – **New Development**

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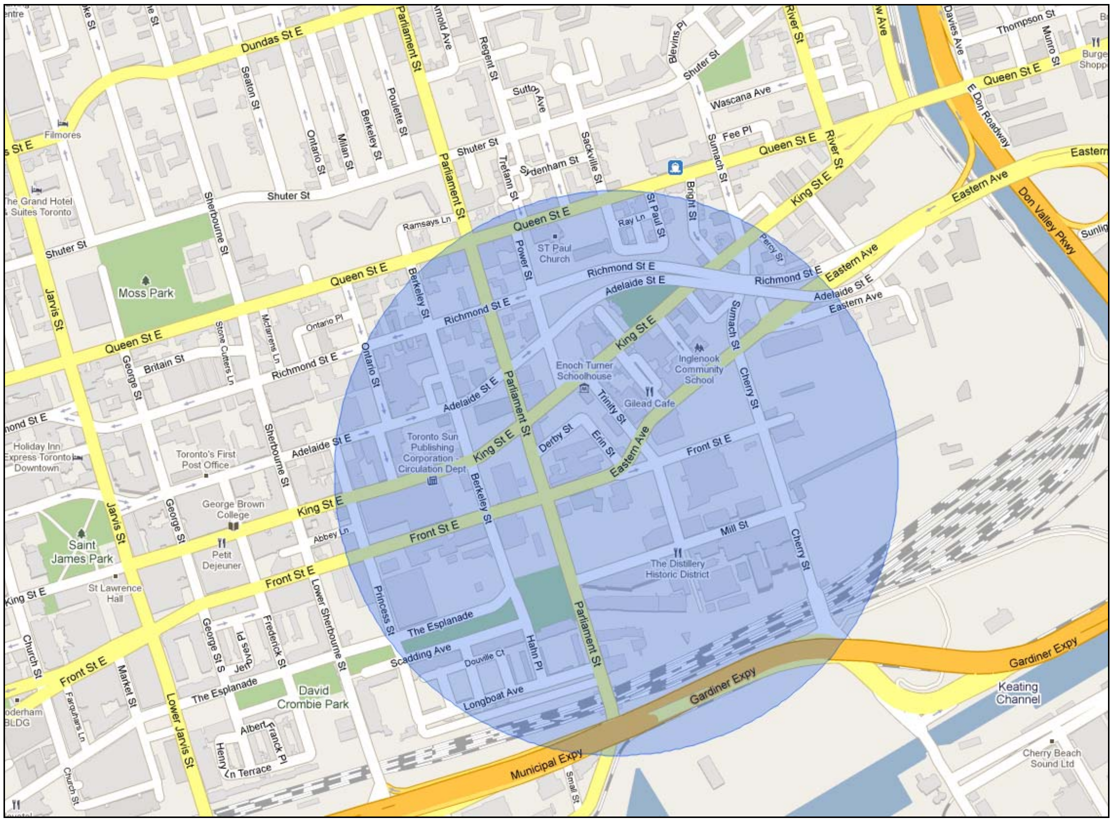
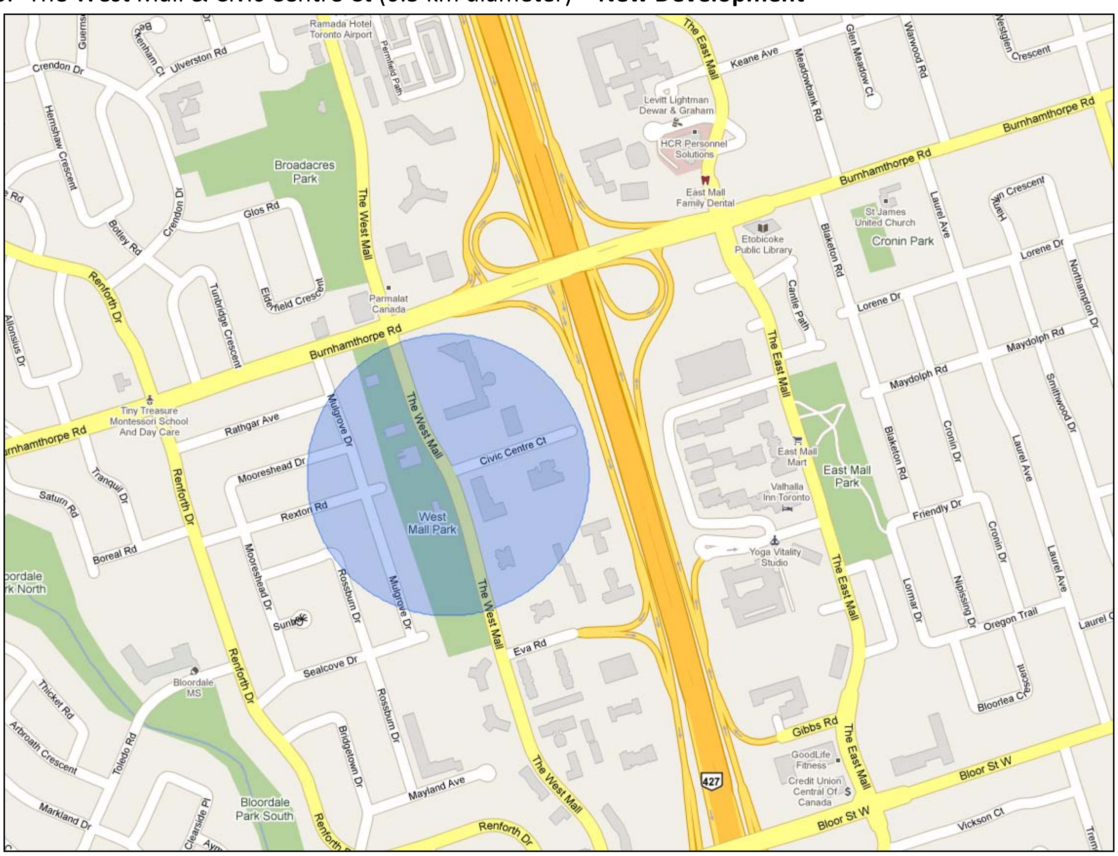
25. Front St & Eastern Ave (1km diameter) – **New Development**



26. The West Mall & Civic Centre Ct (0.5 km diameter) – **New Development**



Addendum D: Individual Maps of 27 Potential DES Nodes

27. Westwood Theatre Lands – Bloor St W and Kipling Ave (1km diameter) – **New Development**

GENIVAR

Potential District Energy Scan in the City of Toronto
Report FA520525 FINAL

October 1, 2010

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1. Scope of Work

This report intends to review the City of Toronto's challenges relative to Clean Energy in context of its success criteria. It then seeks to review the benefits of District Energy Systems (DES) relative to conventional Business As Usual (BAU) design and offer energy node considerations of where and how DES may be effectively implemented. This assignment shall be viewed as Phase 1 of a multi-phase assignment. In Phase 1, GENIVAR shall;

- Prepare an appropriate definition of node to suit the City of Toronto success criteria
- Develop a proposed weighted screening criteria matrix to undertake a high level review of the various identified locations in the City that fit the criteria developed for node selection. These top ranked potential District Energy projects would proceed to further Phase 2 evaluation
- Identify current and future programs for technical and funding support
- Review coordination of complementary technologies including
  - Demand Response
  - Combined Heat and Power (CHP or Cogeneration)
  - Geothermal and
  - Thermal energy storage

Future Phases of the assignment (not in this contract) would expand on short-listed sites with conceptual designs, cost estimates, feasibility to enable a business case to be made for the City to implement the project(s).

1.1 Reviewed Documents

The following documents were provided by the City of Toronto for our review during this assignment.

- Ontario Power Authority District Energy Research Report, prepared by Compass Resource Management Ltd, February 2010
- The Power to Live Green – Toronto's Sustainable Energy Strategy, Prepared by City of Toronto, October 2009
- Advancing District Energy Development in Canada – A Process for Site Selection, Review and Community Participation, prepared by CDEA, September 2007
- Energy Efficiency and Beyond – Toronto's Sustainable Energy Plan – Staff Background Report, prepared by Energy Efficiency Office, June 2007

GENIVAR also reviewed Developing a Downtown District Energy System for the City of Guelph Using a CHP Facility, prepared by MCW Consultants Ltd., 2010

2. Background

2.1 Challenges

The City of Toronto's experience in District Energy Systems (DES) is extensive - about 100 years – dating from TDHC (now Enwave Energy Corporation) through to the recent Toronto Community Housing Corporation (TCHC) Regent Park. The City of Toronto faces new challenges which may be addressed by the implementation of DES and CHP;

- Ever increasing electrical loads within Toronto (resulting primarily from population growth and increased connected loads per person) will continue to add strain to the existing transmission infrastructure into the City. Security of supply was most evident during the blackout of 2003
- Ontario's fleet of coal fired power plants will be phased out by 2014 and the existing fleet of nuclear power plants is approaching 40 years of age. Hence there is forecast shortage of electrical energy generation in the future
- Recognition of increasing extreme weather events in the Province of Ontario which are linked to increased fossil fuel pollutants of exhaust

Currently in Ontario, there is no policy which governs DES - unlike gas and electrical utilities which are regulated by the Ontario Energy Board.

The Ontario Power Authority (OPA) FIT program currently has incentives and policy for renewable energy (which includes biomass and biogas CHP projects) but lacks a Clean Energy Standard Offer Program (CESOP). The CESOP program is expected to be introduced in November 2010 and offer an appropriate long- term guaranteed power purchase agreement for DES and CHP projects under 10 MWe.

There are other 3rd parties who may offer technical and financial support of District Energy Systems including Toronto Hydro, Building Owners and Managers Association (BOMA), Federation of Canadian Municipalities (FCM), Enbridge, Natural Resources Canada (NRCAN), and Canadian District Energy Association (CDEA).

2.2 Success Criteria

City of Toronto is interested in implementing a few district energy solutions within a 2 to 3 year timeframe provided it must satisfy a 3 pillar success criteria approach as follows:

1. Must achieve significant CO_2 reductions relative to conventional design practice – particularly addressing shortfalls in 2050 of approximately 3.9 million tonnes with full implementation of all other initiatives including energy management, green energy, coal phase out, etc.
2. Must make business sense – 9 to 10 % ROI
3. Must support energy security initiatives of the City – currently in need of a third line to take the burden, lessen the strain and offer redundancy to Mamby TS and Leaside TS – if either is lost, the City could be 300 MW short of generation. Generally speaking the need for the 3rd line is driven by provincial electrical load peaking during the summer months. Initiatives to mitigate this have included:
    - Embedded Generation Peaking (i.e. Portlands Combined Cycle) and Combined Heat and Power (i.e. University of Toronto)
    - Energy Management
    - Time of Use Billing (recognition that electricity consumed during peak hours is more expensive to generate and requires a higher amount of installed capacity in the Province)
    - Enwave Energy Corporation Deep Lake Cooling

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- Demand Response
- Geothermal
- Thermal Storage
- Absorption Cooling

3. Business As Usual Case

From the Business As Usual (BAU) perspective, developers design commercial, institutional or residential buildings to be stand-alone with dedicated building services as follows:

- Natural gas boilers for space and domestic hot water heating and;
- Electricity for cooling (by chillers or roof top air handling units) and consumer appliances. There are also still older facilities which continue to utilize electric heating

While each type of building has different electrical and thermal load profiles, the heating and chilling equipment is generally sized to the ASHRAE 99% weather data for maximum rating and equipment selection of the facility - which is only needed for 1% of the year. For the balance of the year, the oversized conventional equipment typically operates in less efficient High – Low - Off mode. Hence, for example, boilers with performance datasheets quoting 80+% efficiency (at peak load) are frequently only achieving 60 to 65% efficiency over the year. This is analogous to operating a car at under stop and go city conditions. This is termed seasonal efficiency and is reflective of significant diversity of loading through the day and the seasons.

From The Power to Live Green, it is agreed that continued development in BAU protocol will miss the 2050 GHG Target Emission Level by 14 Megatonnes per year.

3.1 Enhancements of BAU Design

3.1.1 Energy Management Initiatives

The prevalence of energy management initiatives (most notably VFD technology, high efficiency motors and lighting, Building Automation Controls and motion sensors, etc.) has enabled recent buildings to achieve greater utility efficiencies and their occupants to realize greater comfort than previous building designs.

The City of Toronto, and others, have been successful in instilling these design principles in the past decade into new buildings and retrofitting some of these initiatives into existing developments. However it is estimated that a very high percentage (80% per City of Toronto documentation) of existing vintage buildings will survive into the 2020 to 2050 timeframe.

While it is more feasible to displace a kW of electricity through energy management than to build its capacity in a typical power plant, the cost of retrofitting energy management into existing development will increase with greater complexity of measures (i.e. many of the easy to implement and fast payback initiatives likely have already been implemented). **However efforts to continue to increase energy efficiency for new development must be maintained to continue to challenge designers, equipment manufacturers and developers.**

With CDM initiatives alone, the City of Toronto will not meet its 2050 CO_2 reduction goal and fall short by 4.6 Megatonnes per year. Further enhancements are necessary.

3.1.2 Integrated Design Process and Solar Energy

Beyond energy management initiatives, a further reduction in environmental footprint requires application of an IDP (Integrated Design Process) or IBD (Integrated Building Design) with very high performance /very low energy design. This would be achieved through consideration of;

- Very heavy levels of insulation – possibly a double skin
- High performance glass
- Good construction to minimize infiltration

- Very efficient building services equipment with best-in-class technologies to achieve the resultant loads
- Enhanced LEEDS design philosophy in building design and construction
- Thermal base loading of the facility with solar thermal, recovered industrial waste heat, and/or geothermal energy to offset utility consumption
- Integration of Solar PV at the design stage into the building's façade and roof. Since grid power security is most at risk on high temperature sunny days in summer, there is merit to maximize Solar PV capacity as close as possible to the critical electrical load
- Appropriate use of sky lighting in building design enables use of natural light during the day at a time when electricity to power lighting (and cooling its associated heat gain) is at a premium

There have been significant improvements in both the thermal performance of materials as well as glazing. The idea behind this is to try and minimize the heat loss through the building perimeter to the point where heating is almost eliminated. This will require very high performance glazing systems that are at least R4 or perhaps use of double skin facades (DSF) with thermal inertia.

It is recommended that City of Toronto continue to influence better building design through Tier 1 and Tier 2 City of Toronto Green Building Standards exceeding the minimum MNECB requirements. We agree that City of Toronto recognize these initiatives by enabling the developer to recover 20% of the development charges and enjoy a faster review process.

3.1.3 Demand Response

During peak periods of extremely high Provincial electrical load (and high strain on the incoming power lines to the City of Toronto), the Demand Response Program (offered by Rodan, etc.) seeks to encourage building owners to shed non-essential electrical load and / or operate existing embedded stand-by diesel generators (with appropriate emissions abatement and electrical auto-transfer equipment). Powerstream also offer thermostats which allow remote set point adjustment by the utility of the user's air conditioning equipment during peaking.

These programs have had some success, but it remains a challenge to encourage the public to accept the load shedding protocol into their lifestyle. It also requires incentives to encourage and metering to enforce and compensate the practice.

There is merit to consideration of establishing an improved design practice of identifying and isolating critical loads (refrigeration, etc.) from non essential loads. During peaking events, this would enable more effective;

- Sizing of standby-equipment to critical load and;
- Shedding of non-essential load

It is recommended that new facilities be designed with an electrical distribution system which enables essential loads to be minimized and isolated easily from non-essential loads to ease load shedding.

3.1.4 Geothermal

Indirect Geothermal Ground Source Heat Pump is a prevailing technology to utilize the thermal properties of the earth to offset a portion of the facilities' thermal loads. While this technology is fairly recent, it is gaining acceptance in remote settings and certain new suburban low to medium density residential developments. Recently it has been installed in highly urban settings.

While it is more difficult to retrofit this technology into existing developments and equipment, it is worth consideration for new Greenfield or Brownfield developments – particularly where large commercial parking lots or residential parks may be beneficial for hosting expanded geothermal wellfields.

Implementation of this technology requires a series of ground heat exchangers buried within the soil which are interconnected with water to air heat pump circulating antifreeze under the soil. These vertical wellfields consist of wells typically 200 to 600 feet deep. However, it is imperative that accurate soil conditions are known to assess feasibility of the technology and sizing. Exceptionally dry soils are not appropriate.

For average Toronto conditions, 150 to 200 feet of well is required per refrigeration ton. Based on 200 feet (60 metres) of well / refrigeration ton, and $15 to 17 per linear foot of well, the technology is approximately $3,400 / refrigeration ton. This is well above the price of conventional refrigeration equipment and generally does not provide a ROI in the desired range of the City of Toronto Success Criteria.

Frequently the electrical load of pumping throughout the year offsets the electrical benefits of the measure and savings are therefore associated with reduced emissions of natural gas heating.

However, it is recommended that this technology be incorporated in tandem with thermal storage initiatives.

3.2 Summary of BAU

By review of the BAU designs and possible enhancements, it is clear that 2050 Emission Goals and energy security concerns will not be solved with ever increasing population and electrical loads will continue to strain the incoming electrical infrastructure to the City of Toronto.

4. District Energy

Relative to BAU, DES provides better ability to increase seasonal efficiency and incorporate thermal storage through economies of scale and diversities of connected load profiles. This is realized by linking discrete buildings and activities together through a thermal network and aggregating the varying energy demands into a more steady profile. This enables the equipment to operate at a more efficient steady state versus BAU. This is analogous to operating a car at steady state highway conditions and is also more efficient and easier on the equipment in terms of extended life and reduced wear.

A DES consists of 3 main sub-systems as follows:

- The central heating/ cooling plant – this may consist of conventional high efficiency boilers and chillers or may feature Combined Heat and Power (CHP) or tri-generation. The boilers may be hot water or steam and condensate. Generally most new DES is hot water based
- The district energy piping network – generally 2 or 4 buried and insulated pipes and associated valve chambers
- The customer's interconnection point where the heating and/or cooling is metered and energy exchanged to the building's isolated loops. This metering and central monitoring enables energy consumption trending and benchmarking upon the network

A DES offers the following benefits;

- Provides heating and/or cooling from a central plant to a network of residential, commercial, institutional, or industrial buildings. This central plant may be more remote to sensitive receptors and provides an economy of scale opportunity to consider more robust building construction for superior noise reduction and security
- Offers economic and environmental benefits versus BAU design
- Enables greater utilization of property development as occupied space rather than mechanical and electrical rooms
- Enables a higher degree of redundancy for equipment back up. Larger equipment in a single location also provides opportunity for enhanced combustion technology or "end of pipe" abatement technology for reduced greenhouse gas emissions and improved dispersions
- Offers enhanced operation and maintenance programs by more qualified staff and the ability to offer consideration to thermal optimization, alternative energy inputs, energy benchmarking and monitoring and targeting

DES is a very mature technology and is more prevalent in Europe where fossil fuel is scarce and resultant energy pricing has been significantly higher than North America for a very long time. DES is relatively expensive (with additional cost and coordination to implement district energy piping) and together with financial risks of securing and maintaining clients, tends to prohibit private enterprise implementation. Therefore the resultant payback for DES has been much longer relative to BAU.

DES is more frequently implemented in high density clusters of government or institutional buildings by levels of government who are able to carry long term debt. Examples include Toronto District Heating Corporation (now Enwave Energy Corporation), Public Works and Government Services (7 DES systems in Ottawa), Markham District Energy, City of Guelph, etc.

Further to the success criteria of the City of Toronto to reduce emissions and increase energy security into the core, implementation of DES offers considerations of options which would

otherwise typically not be achieved through BAU design. This includes staged utilization of enhanced technologies as discussed in the following sections.

4.1 Enhancements of District Energy Designs

As mentioned, a basic DES will utilize conventional infrastructure – high efficiency boilers and chillers – delivering hot and chilled water through its distribution system. These systems are highly reliable and efficient and currently are the basis of many systems including Markham District Energy's Clegg Road and Birchmount Energy Centre (with CHP embedded in Warden Energy Centre) as well as Enwave Energy Corporation and Toronto Community Housing Regent Park (with provisions for future CHP).

While these DES address City of Toronto's initiatives for emission reductions, they do not address energy security concerns into the City. For this, it is necessary to assess enhancements which feature embedded generation as discussed in the following sections.

4.2 Combined Heat and Power

A feature of DES which is distinct versus the conventional Provincial Utility power generation model is the addition of a thermal distribution system with users who value the recover heat for space heating, domestic hot water or process uses. Hence rather than a plant which is 40% efficient relative to its electrical efficiency potential, a CHP plant can achieve combined efficiencies of 80 to 90% by recovering waste heat and utilizing it in addition to its electrical energy produced. In Europe, CHP is a prevalent technology of urban centres and also features further refinement with Energy From Waste (EFW) initiatives.

From an electrical perspective, to reduce provincial transmission losses, current accepted estimates state that 5 to 7 % of energy generated is lost through transmission. For 26,000 MWe of Ontario provincial peak load, this represents 1300 to 1950 MWe of losses which may be offset with CHP embedded generation at the point of consumption rather than remote.

In Ontario, there are numerous examples of CHP ranging from 250 kWe to beyond 500 MWe.

- Smaller plants – in the 250 kWe to 5 MWe tend to be embedded in unique hosts – often industrial where the electricity generated is used to reduce (displace) electrical purchase from the utility and the waste heat is recovered to displace boiler thermal loads in heating processes. Examples of this include Labatt London, Heinz Leamington, Sanofi Pasteur, and numerous greenhouses in Niagara (Tage Hansen, Rosa Flora, etc.)
- Larger plants are generally configured as combined cycle where gas turbine exhaust waste heat is recovered as steam for admission to a steam turbine generator. These plants (Portlands, Sarnia, Thorold, etc.) generally operate in peaking mode when dispatched from the OPA relative to requirements of the Provincial Grid. They do not typically interconnect to DES

Generally for CHP, 5 to 10MWe is the target threshold for economies of scale to be realized in DES and is the size range of Markham, and Guelph. Recognizing challenges of citing large CHP DES plants within the City of Toronto in terms of potential resistance from residents, this report will focus on appropriate size parameters from which the OPA CESOP will likely focus – 10 MWe and under.

CHP which is utilized in DES is typically of the Topping Cycle configuration – a single source of fuel is primarily focused on electrical power generation from the coupling of the engine to an electric generator, and waste heat which is captured in a waste heat boiler to recover steam or hot water.

Prime movers for CHP are summarized as follows;

- Gas Engine –
    - Mature technology - in smaller size ranges, up to about 5 MWe, gas engines have many benefits compared to gas turbines – higher efficiencies, better part load efficiency, and

ability to utilize low pressure natural gas (without parasitic requirement and noise of a dedicated natural gas compressor)

- Manufacturers (including Caterpillar and GE Energy) package complete skid mounted cogeneration packages with engine, generator, controls, heat recovery equipment, acoustic enclosures, and silencers
- Robust, slow speed design (900 to 1800 rpm) enables long expected life cycles up to 20 to 25 years with appropriate maintenance. Guaranteed maintenance contracts are available by manufacturers
- Units may be rapidly started up on call
- In addition to natural gas, engines may be configured to run on alternate fuel sources
- Have higher maintenance requirements than gas turbines but may achieve up to 8000 hours per year (92% availability)
- Limited to low pressure steam and hot water in the form of recovered heat However most DES are configured in hot water to achieve a slight efficiency improvement versus steam

- Gas Turbine
    - Mature technology – in size ranges above 7 MWe, gas turbines achieve better electrical efficiency that engines
    - Gas turbines are more compact than gas engines and the entire gas turbine may easily be swapped out for improved availability – up to 8400 hours per year (96% availability)
    - Poor part load efficiency if the DES thermal load requires the prime mover to operate at part load
    - Greater flexibility in recovered heat – high pressure steam may be recovered
    - Not as flexible as gas engines for frequent start up and shut downs. Start up times are much longer and frequent shut downs are problematic for long service duty
- Direct Driven Equipment - In rare situations, an engine may be directly coupled to an electric chiller to offset the electrical consumption of an electric motor. This offers energy security in summer months when electrical distribution into the City is strained and natural gas distribution is underutilized. These installations are rare as they require close collaboration of an engine manufacturer and chiller manufacturer upon a single skid with an appropriate control system.

Owing to their sensitive sizing criteria for optimized payback, CHP is often not implemented initially into the DES. Space and interconnection provisions are allowed to enable CHP to be easily configured at a time when thermal loads are established and contracts are secured. At that time the sizing of the CHP may be optimized to enable operation in base load with “thermal load following” protocol – i,e. prime movers are operated at loading such that all available waste heat is recovered and utilized to displace gas fired equipment. Hence the Phase 1 development of DES typically features conventional boilers and chillers. This capacity is then available as back up and peaking service for when CHP is later implemented. This has been the practice at Markham District Energy as well as Regent Park.

4.3 Thermal Load Optimization Considerations

As noted in the previous section, it is imperative that CHP DES operate in harmony with electrical and thermal loads. CHP equipment is not cost effective without full credit for recovered heat, nor does it meet the City’s success criteria. Reduced operation of the CHP during periods without a thermal load stretches out the payback period of CHP.

Institutional, Commercial and Multi-Residential developments have similar thermal loads profiles with slight variations when the domestic hot water is utilized (see Section 5);

- Significant peaks in the winter months relative to the space heating requirements of winter
- Shoulder seasons in the spring and fall when heating requirements fluctuate significantly on a daily and weekly basis
- Significant low points in summer when space heating loads are removed and only domestic hot water loads remain

Industrial process loads tend to be stable for 16 to 24 hours per day and 5 days per week. This base load is desirable to flatten the DES thermal load throughout the year and enable the CHP utilization to be maximized – preferably to coincide with the duration of the time of use peak rate electricity charge.

4.3.1 Absorption Chilling

Absorption chillers utilize thermal energy (typically steam or hot water) as the energy input to produce chilled water. To achieve economies of scale in CHP requires more aggressive sizing than the base summer thermal load and reduced summer operation. Hence absorption chillers utilize recovered CHP heat during seasons when the DES does not require heat and offsets electrical energy to drive electric chillers during the summer when the DES electrical load – and the Provincial Electrical Demand – is at a peak. This is a type of CHP which is also referred to as Tri-generation – three sources of energy (electricity, heating and cooling) from a single energy source.

Absorption chilling equipment is more expensive than conventional chillers and is utilized only 4 to 5 months of the year. This then increases the payback period of the CHP and reduces the ROI. These are the common reasons why they are not incorporated – and a significant reason why the City of Toronto's electrical incoming feeders are strained in the summer.

Relative to the City of Toronto's success criteria, absorption chilling;

- Directly reduces peak electrical load
- Enables CHP DES to operate over a longer interval of the year – particularly when the anticipated revenue of the CESOP program will be highest (summer months during peak rates – Monday to Friday from 6AM to 9PM), and
- Improves energy security to the City

York University, Markham District Energy, Ontario Realty Corporation (Stone Road and Ontario Police College) all feature CHP within their DES together with absorption chillers in the 3 to 10 MW size range.

4.3.2 Thermal Storage

Chilled Water Storage

Chilled water storage systems are utilized to reduce chiller equipment sizing and to shift electrical load from peak to off peak intervals. From the City of Toronto's perspective this has the effect of reducing the strain on the incoming lines to the City during peak loading.

Massive tanks of ice or brine serve to store chilled water produced during the evening or weekends when electrical cost is reduced and pump it during peak hours. Modest amounts of supplemental cooling may be required as needed.

There are a few examples of this technology installed, but it is recognized that the initiative uses approximately 15% more energy to compensate for the additional pumping and heat gain in storage. An interesting solution may be considered. Recognizing the reduced cooling load on the Enwave Energy Corporation Deep Lake Cooling System during evening hours, this additional capacity may be more fully utilized by accessing new buildings in tandem with thermal storage. This would also reduce summer peak loading and associated strain and emissions.

Chilled Water Storage is recommended for further consideration on a site specific basis – particularly where physical space exists for storage, it is feasible to interconnect to the Deep Lake Cooling System and in regions of the City which are electrically constrained.

Hot Water Storage

Hot water storage systems are utilized to offer;

- A short term storage buffer in fluctuations of the domestic hot water heating load of facilities
- An opportunity for CHP plants to maximize their thermal load following operation into the summer peak load and store thermal load for utilization during non peak hours when residential customers draw hot water for dishwashing, clothes washers, bathing and showers, swimming pool warming, etc.

It is recommended that this technology be adopted. This is a mature technology and the slight inefficiency of storage (similar to chilled water storage, above) is at the lower expense of thermal energy (rather than electrical energy).

4.4 Alternative Energy Input Considerations

With DES and their associated size and equipment, there are opportunities to introduce alternative renewable fuels to displace natural gas as the base input.

4.4.1 Biomass

Note that there is speculation that the current OPG Coal-Fired power plants may be refurbished to utilize biomass. The size of these facilities and the current underdeveloped biomass market may be a challenge to biomass utilization within a City of Toronto District Energy Plant. Furthermore, there are unique challenges for development of DES with biomass which include;

- Permitting
- Emissions
- Truck traffic
- Fuel storage
- Biomass price fluctuation as the demand increases

At this point, biomass utilization in a DES may be deferred until the DES is developed, CHP is implemented and the biomass industry is matured.

4.4.2 Digester Gas

Digester Gas from municipal water treatment is a proven source of renewable energy and currently there are utilization initiatives at City of Toronto’s Humber and Ashbridges Bay Water Treatment Plants. Full utilization of this energy source shall continue to be pursued as it directly achieves the success criteria of the City of Toronto.

Most of this recovered electrical and thermal energy is parasitically consumed in the digestion and space heating loads of the Treatment Plants. Furthermore there is limited retrofit opportunity for district energy in these existing established neighbourhoods.

4.4.3 Landfill Gas

There are no known operating landfills which are either operating or planned within the limits of the City of Toronto. Current examples of successful landfill gas power plants are beyond the limits of the City of Toronto and include Keele Valley, Brock Road and Beare Road Landfills.

4.4.4 Industrial Waste Heat Recovery

Data management centres, foundries and glass manufacturers are a few examples of industries with an abundance of high grade heat which is often wasted. Consideration of recovery of this waste heat is a potential win – win scenario:

- The district energy plant is able to recover and distribute this heat and displace natural gas and reduce emissions, and
- The industry is able to improve its efficiency by not requiring to use energy in cooling towers, air cooled condensers, etc. to cool the medium

Generally though these scenarios are somewhat rare and there may be reluctance of the industrial host to accommodate the disruptive efforts to implement these costly measures and finance them. There is also a current trend for industrial hosts to leave downtown cores and existing industrial hosts often have implemented heat recovery or deemed it to be impractical. To help support this initiative, it would be desirable to implement a form of Standard Offer Contract for heat sources to feed into DES. We understand from City of Toronto that this is being explored.

It is desirable to be able to interconnect to an industrial user into the DES and/ or develop a CHP within this host.

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4.5 Summary

The following table is intended to summarize the technology considerations presented in this section relative to the City of Toronto Success Criteria.

Table 4-1 Summary of District Energy Technology Considerations

Feature	Ability to Reduce CO2 Emissions	Achieve an Appropriate ROI	Energy Supply Security Initiatives	Comments
Business as Usual (BAU)		Base case		
Energy Management				**PROS** - Ability to achieve all City of Toronto Success Criteria **CONS** - none
Demand Response				**PROS** – Limited generation at point of consumption. Non-essential load is shed. **CONS** – Generation is by diesel equipment.
Geothermal				**PROS** - Gaining acceptance in urban settings **CONS** - Limited by reduced land in urban developments
Thermal Storage				**PROS** - Offers ability to load shift to off peak with geothermal and to expand Enwave Energy Corporation Deep Lake Cooling System **CONS** - Space intensive and less efficient
District Energy (DES)				
with Combined Heat and Power (CHP)				**PROS** - Ability to achieve all City of Toronto Success Criteria **CONS** – Somewhat expensive and reliant on appropriate sizing and long term contact.
with CHP & Absorption Chilling				**PROS** - Decrease the Provincial electrical peak of the summer months **CONS** - Price premium to utilize absorption equipment
with Alternative Fuels as the base energy input				**PROS** – Considered a carbon neutral technology **CONS** - Uncertainty of biomass pricing in future, citing constraints
with waste heat recovery from industrial				**PROS** – Win – win scenario **CONS** - ROI dependent upon the viability of the industrial host
with thermal storage				**PROS** - Offers ability to load shift to off peak with geothermal and to expand ENWAVE Deep Lake Cooling System **CONS** - Space intensive and less efficient

5. Characteristics of a District Energy Node

In this section, we will comment on desirable criteria of a node upon which the City of Toronto may consider to enable appropriate DES to be implemented in accordance with their success criteria.

5.1 Composition of Preferred Node

For the City of Toronto, the priority focus for node development would be;

- In a Greenfield, employment land or Brownfield development, to enable building services design at the outset to better utilize DES thermal design criteria rather than expensive retrofit of existing buildings
- High density development to reduce cost of thermal distribution and to provide an anchor client upon which a reliable and stable base load may be established
  - Institutional facilities such as Hospitals, Colleges, Universities, Blood-Supply Centres, Medical and Pharmaceutical Storage Facilities, Recreation Centers offer high density and require special consideration of security of energy supply
  - Existing or proposed Industrial clients and data management centres are desirable to enhance thermal distribution and to flatten the shape of the season thermal load
- Enhanced communities which are supportive of close proximity of living, playing and working environments to further reduce transportation emissions and foster walking and cycling
- Tenants or residents with a culture of energy management
- Located within an electrically constrained distribution region of Toronto which would otherwise necessitate transmission upgrades. Demand side reduction and embedded cogeneration will reduce the transmission limitations into the city and strain on the existing transmission stations
- Appropriate land for consideration of geothermal and thermal storage considerations
- An appropriate Natural Gas supply complemented by an opportunity to utilize the following alternative energy sources to reduce its environmental footprint
  - Industrial waste heat
  - Biogas (landfill, water/sludge treatment plant, composting plants)
  - Biomass (composting plants, parks, yard waste collection points)
  - Interconnection to the Enwave Energy Corporation Deep Lake Cooling system if accessible May also be beneficial to utilize off peak underutilized cooling capacity of Deep Lake Cooling in conjunction with thermal storage

Special consideration may be given to interconnecting existing developments with unique triggers which may include;

- Existing boilers and/ or chillers which are nearing the ASHRAE predicted reliable service life of 20 to 25 years
- An existing chiller with phased out refrigerants – note in addition to environmental benefits, these older units tend to be inefficient from an energy perspective – particularly at part load
- A boiler which is unable to achieve appropriate emission performance relative to NOx and CO_2
- Nearby utility networks to be replaced (water, gas, electricity) and /or road redevelopment within 2-3 years

- Proximity to existing DES

5.2 Determination of Node Energy Profile

Energy profile is a main factor to be evaluated when considering opportunities for DES and is represented by the electricity, heating and cooling requirements of a structure, its inhabitants and its usage. When a high level analysis is performed, as for the present study, average energy demand intensities (ekWh per square meter per year) for space heating, space cooling and electrical consumption provide the starting point. Further consideration of specific building characteristics and energy profiles can then refine the accuracy.

- For existing facilities, a detailed time of use analysis of the utility bills and a condition assessment of the existing mechanical system installed is required
- For new development, detailed energy models based on the proposed design can provide data with the required accuracy

As energy standards and construction practices have improved, the energy demand of building decreases. The following milestones support estimating the required energy for different nodes:

- **2006** – The Ontario Building Code (OBC) updated the energy efficiency requirements and design must achieve ASHRAE 90.1-1999 Standard
- **January 2010** – The City of Toronto introduced the Toronto Green Energy Standard with a mandatory Tier 1 level and voluntary Tier 2 level
    - *Tier 1:* design must result in energy consumption 25% less than what prescribed by the Model National Energy Code for Buildings (MNECB) or 13% less than what prescribed by the Ontario Building Code. The Tier 1 energy requirements are equivalent to the requirements for LEED certification under the EA prerequisite 2
    - *Tier 2:* design must result in energy consumption 35% less than what prescribed by the Model National Energy Code for Building (MNECB). The Tier 2 energy requirements are equivalent to the requirements for LEED certification and achievement of 3 points under the EA credit 1

As DES opportunities are generally much stronger for high density districts, buildings such as mid-high rise commercial and residential are preferred. This is also representative of large facilities such as hospitals, universities, institutional buildings, etc. Based on the above considerations, six building types are considered and presented in Table 5.1:

- Existing Building Commercial / Residential (complying OBC 2006)
- New Building Tier 1 Commercial / Residential
- New Building Tier 2 Commercial / Residential

Energy demand intensities estimates for space heating, space cooling and electrical consumption for each of the building type are then weighted to create the building type mix that best represent the investigated area. In this way the energy intensities for a typical building cluster (energy node) are created.

The selection of the technology and basic parameters defines the system size and the available energy output for DES. At this point, the output considered has to match the demand by varying the building area assumed for the typical building cluster**. The resulting development area establishes the minimum building area required by a node.**

Table 5-1 Energy Characteristics of Existing Buildings versus New Buildings

	Existing Building [1]						
	Space Heating	DHW	Peak Space Heating	Space Cooling Thermal Load	Peak Cooling Load	Electrical Demand	Power Demand
	ekWh/m².yr	ekWh/m².yr	eW/m²	ekWh/m².yr	eW/m²	kWh/m².yr	W/m²
1 - Mid/High Rise Commercial Building	101	4	72	91	76	142	58
Mid/High Rise Residential Building	101	29	72	50	46	90	58
	New Building - Tier 1: 75% of consumption as per MNECB criteria [2]						
	Space Heating	DHW	Peak Space Heating	Space Cooling Thermal Load	Peak Cooling Load	Electrical Demand	Power Demand
	ekWh/m².yr	ekWh/m².yr	eW/m²	ekWh/m².yr	eW/m²	kWh/m².yr	W/m²
Mid/High Rise Commercial Building	84	3.0	60	76	63	118	48
Mid/High Rise Residential Building	84	24	60	42	38	75	48
	New Building - Tier 2: 65% of consumption as per MNECB criteria [3]						
	Space Heating	DHW	Peak Space Heating	Space Cooling Thermal Load	Peak Cooling Load	Electrical Demand	Power Demand
	ekWh/m².yr	ekWh/m².yr	eW/m²	ekWh/m².yr	eW/m²	kWh/m².yr	W/m²
Mid/High Rise Commercial Building	73	2.6	52	66	55	103	42
Mid/High Rise Residential Building	73	21	52	36	33	65	42

NOTES:
1 - Existing building are referred to building constructed as per requirements of Ontario Building Code 2006 (ASHRAE 90.1-1999). Source: values calculated from Tier 1 values.
2 - New building complying with Toronto Green Standard/Energy Efficiency/ Tier 1. Source: OPA District Energy Research Report, CompassLtd.; February 2010.
3 - New building complying with Toronto Green Standard/Energy Efficiency/ Tier 2. Source: values calculated from Tier 1 values.

5.3 District Energy Node Model with CHP

From the summary of Section 4, for all success criteria of the City of Toronto to be simultaneously realized – most notably energy security of supply, it is necessary for the DES Node to feature CHP and be implemented in stages to enable growth with new development and stabilization of clients. A mature node may then be configured with CHP and alternative fuel source and thermal utilization strategies.

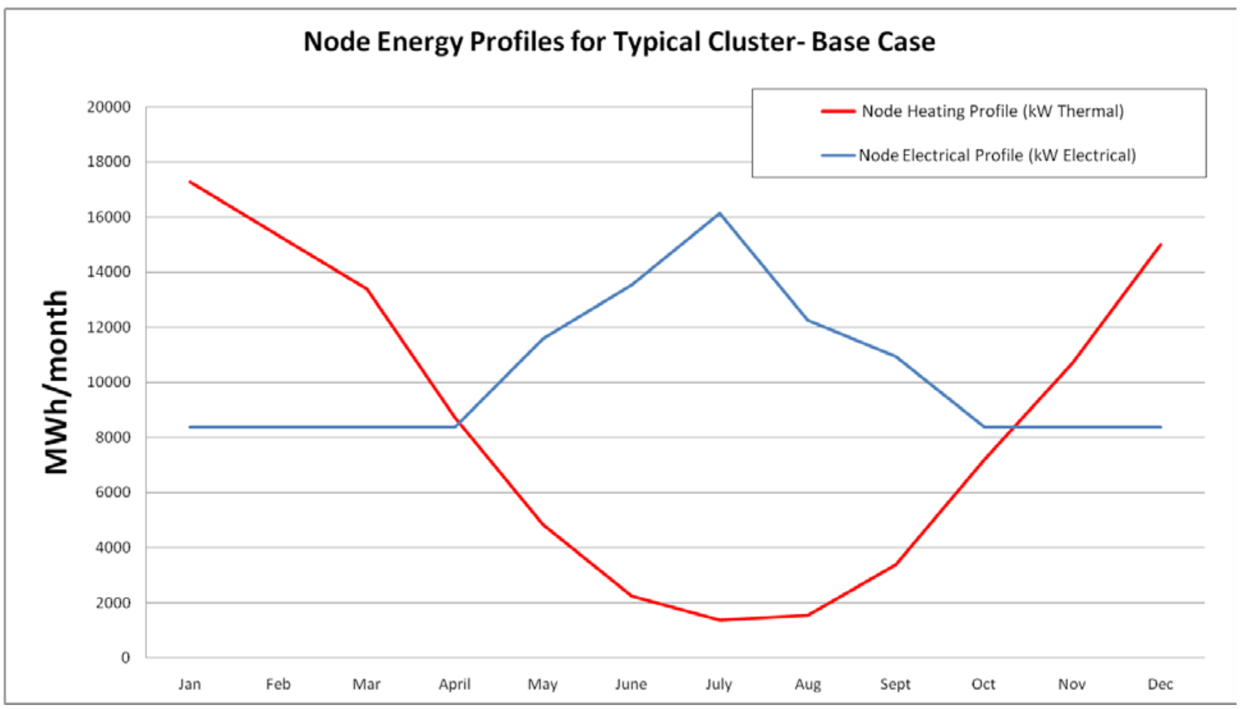
For the CHP to have appropriate economies of scale, it is suggested that an appropriate ultimate model be developed. From the anticipated 10 MWe upper limit of the OPA CESOP program, an appropriate node shall be developed and contrasted with the BAU scenario with the following assumptions.

Node Energy Profile Assumptions

- Analysis of monthly energy levels to account for seasonal variations. Weekly and daily profiles are not considered at this stage
- Typical Building Cluster Composition
    - 50% New Building Tier 1 Commercial
    - 50% New Building Tier 1 Residential
- Node heating profile based on monthly degree-days (<18°C) for Toronto
- Node electrical profile based on base electrical load plus electricity required for space cooling; electric chiller COP is assumed at 2.7

The resulting DES profile is show in the figure below.

Figure 5.1 Node Energy Profiles for DES NODE – Base Case



Energy Supply Assumptions

- Base Load - Cogeneration system:
- Technology: Gas Engine (GE Jenbacher J624 double-stage turbocharger or equivalent). This is a leading efficiency and environmental performance selection which may be doubled for larger developments and still comply with the 10 MWe threshold of the CESOP program.
    - Electrical Output: 4.4 MW electrical
    - Thermal Output: 4.1 MW thermal assuming production of hot water at 70/90°C
    - Electrical Efficiency: 46.5%
- Operation: the gas engine operates in thermal load following to base thermal load during "on peak" hours (to maximize electricity sale revenue). It is assumed 15 hours per day and 5 days per week resulting in an annual average of 11 hours per day of operation
- Back up boilers are installed to supply heat for the mid and peak thermal loads

Resulting supply and node profiles are shown in figures below.

Figure 5.2 Heating Profiles for DES Node - Cogeneration

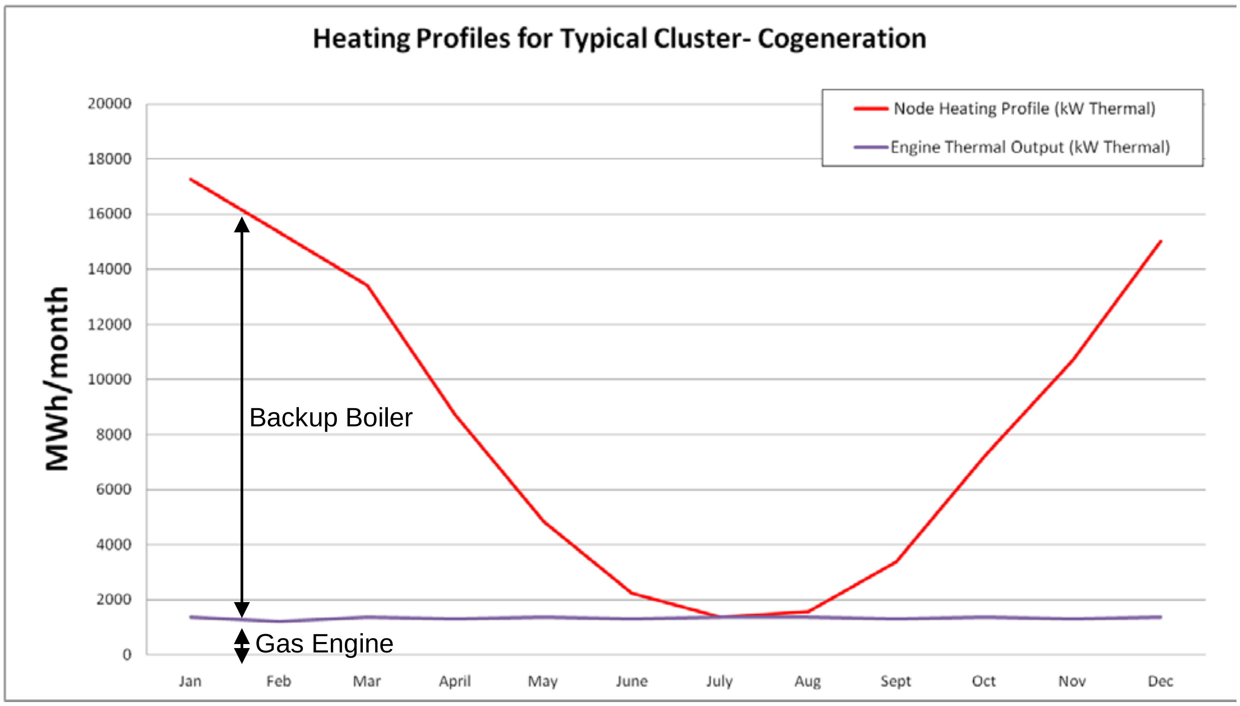
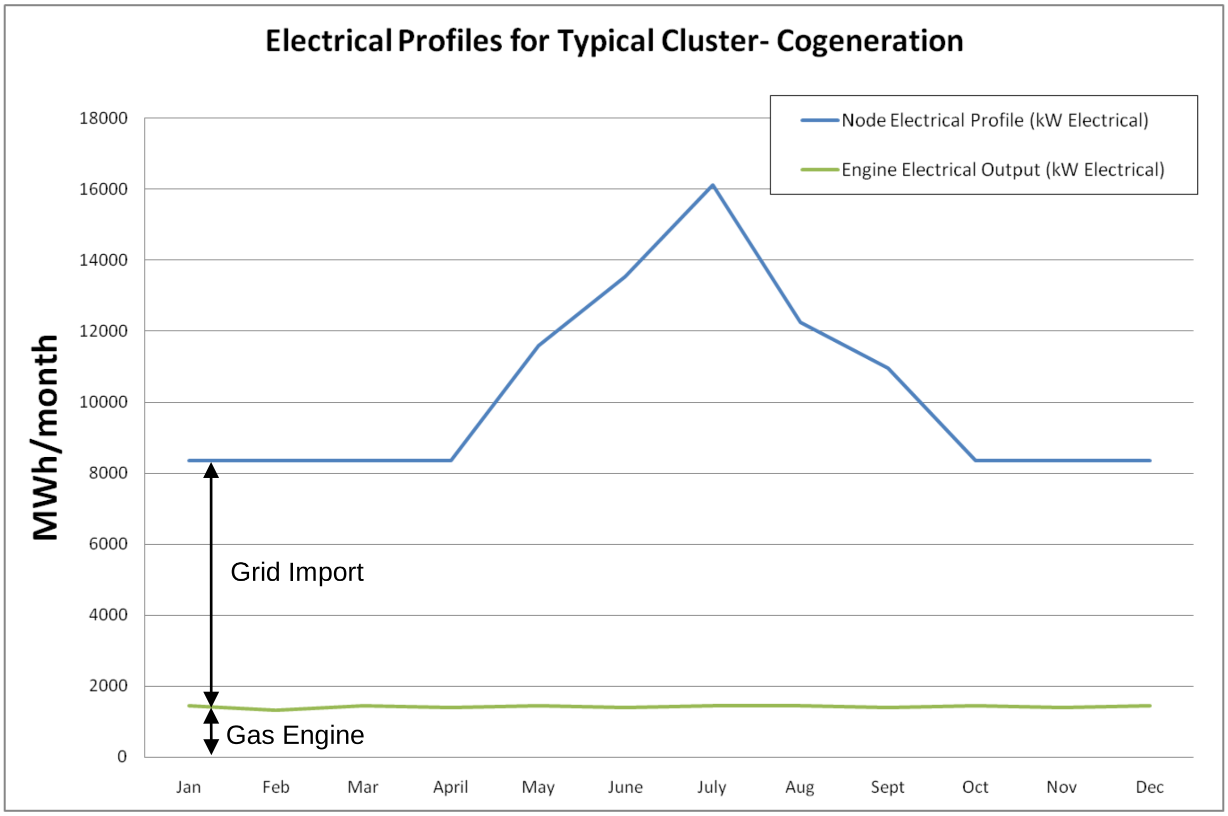


Figure 5.3 Electrical Profiles for DES Node - Cogeneration



Greenhouse Gas (GHG) Emissions Assumptions

GHG emissions are calculated for the Business As Usual (BAU) case and for the Cogeneration district energy option in order to quantify emission reduction within the province of Ontario. For both calculations, the following assumptions are considered:

- A 6.56% loss factor is applied to the node annual electrical requirement to determine the electricity consumption seen at the electricity generator This factor represents Canada's National Average for both transmission and distribution losses
- Emission factor for electricity generation is assumed at 0.200 equivalent CO_2 tonne per MWh. This factor represents the Ontario average for year 2007 as specified by Environment Canada
- Emission factor for natural gas combustion is assumed at 0.184 equivalent CO_2 tonne per MWh of heat as specified by Environment Canada
- Boiler seasonal efficiencies are assumed at 65% for individual boilers (BAU) and 80% for backup boilers

Table 5-2 DES Node - Performance Comparison – Base Case vs. Cogeneration

Base Case (Business As Ususal)				Cogeneration System		
Annual Electricity Demand	MWh/year	123002		Annual Electricity Demand	MWh/year	107012
Transmission Loss[5]	%	6.56%		Transmission Loss[5]	%	6.56%
Annual Electricity Consumption	MWh/year	131637		Annual Electricity Consumption	MWh/year	114525
Emission Factor for Electricity[6]	TonCO_2/MWh	0.200		Emission Factor for Electricity[6]	TonCO_2/MWh	0.200
Annual GHG Emissions from Electricity	TonCO_2/year	26327		Annual GHG Emissions from Electricity	TonCO_2/year	22905
Annual Heat Demand	eMWh/year	101008		Annual Heat Demand	eMWh/year	85018
Boiler Seasonal Efficiency	%	65%		Boiler Seasonal Efficiency	%	80.0%
Annual Gas Consumption	eMWh/year	155396		Engine Electrical Efficiency	%	46.5%
Emission factor for Natural Gas[7]	TonCO_2/MWh	0.184		Annual Gas Consumption	eMWh/year	143175
				Emission factor for Natural Gas[7]	TonCO_2/MWh	0.184
Annual GHG Emissions from NG	TonCO_2/year	28593				
				Annual GHG Emissions from NG	TonCO_2/year	26344
Total GHG Emissions	TonCO_2/year	54920		Total GHG Emissions	TonCO_2/year	49249

NOTE:
5 - Canada National Average
6 - Environment Canada, Canada's National Inventory Report: 1990-2008
7- Natural Resources Canada; http://oee.rncan.gc.ca/industrial/technical-info/benchmarking/ctwp/appendix-a.cfm?attr=5

Specific GHG Emission Reduction	**kgCO_2/m^2 .year**	**5.5**
Total GHG Emission Reduction	**TonCO_2/year**	**5671**
Relative GHG Emission Reduction	**%**	**10.33%**

5.3.1 Summary and Discussion

Assuming the CHP is sized to provide the base thermal demand of the node, the CHP thermal output and DES heat demand should match in the month of July as shown. This will ensure the operation of the CHP is maximized and its efficiency is optimized.

The additional thermal load required on the other months is provided by efficient natural gas fired boilers which operate at a higher seasonal efficiency than single unit. The engine is also generating electricity that displaces a fraction of the electricity imported from the grid as shown. Furthermore, by review of Figures 5.2 and 5.3, it is recognized that the CHP electrical and thermal sizing is small relative to the DES maximum load and its benefits are minimized.

Size of DES Node

The DES node required for the assumptions made in this example is calculated as 1,035,976 m^2. By allowing engine operation down to 65% load, a larger fraction of the electrical and thermal loads can be displaced and the area of the DES node decreases to 673,614 m^2. Prorated engine selections may enable smaller DES to be suitable CHP selections.

Greenhouse Gas Emissions

The proposed example shows a GHG emission reduction of 5,671 tonne of CO_2 per year (within the Province of Ontario), which represents a 10.3% reduction from the BAU scenario. Based on the size of the node, this GHG emission reduction corresponds to an annual reduction of 5.5 $kgCO_2/m^2$. This value is lower compared to the 8.3 $kgCO_2/m^2$ suggested by the Canadian District Energy Association because the cogeneration system covers only the base thermal load as shown in figure 5.2. In addition, emission factor for natural gas combustion and electricity adopted in the model may differ from those used in other studies.

Energy Security

This initiative will embed 4.4 MW of electric power within the City of Toronto resulting in a reduction of the Peak load strain on the incoming transmission infrastructure. The proposed example results in 16,275 MWh/year of electricity fed into the local grid during peak hours.

5.4 Node Development with Tri-generation

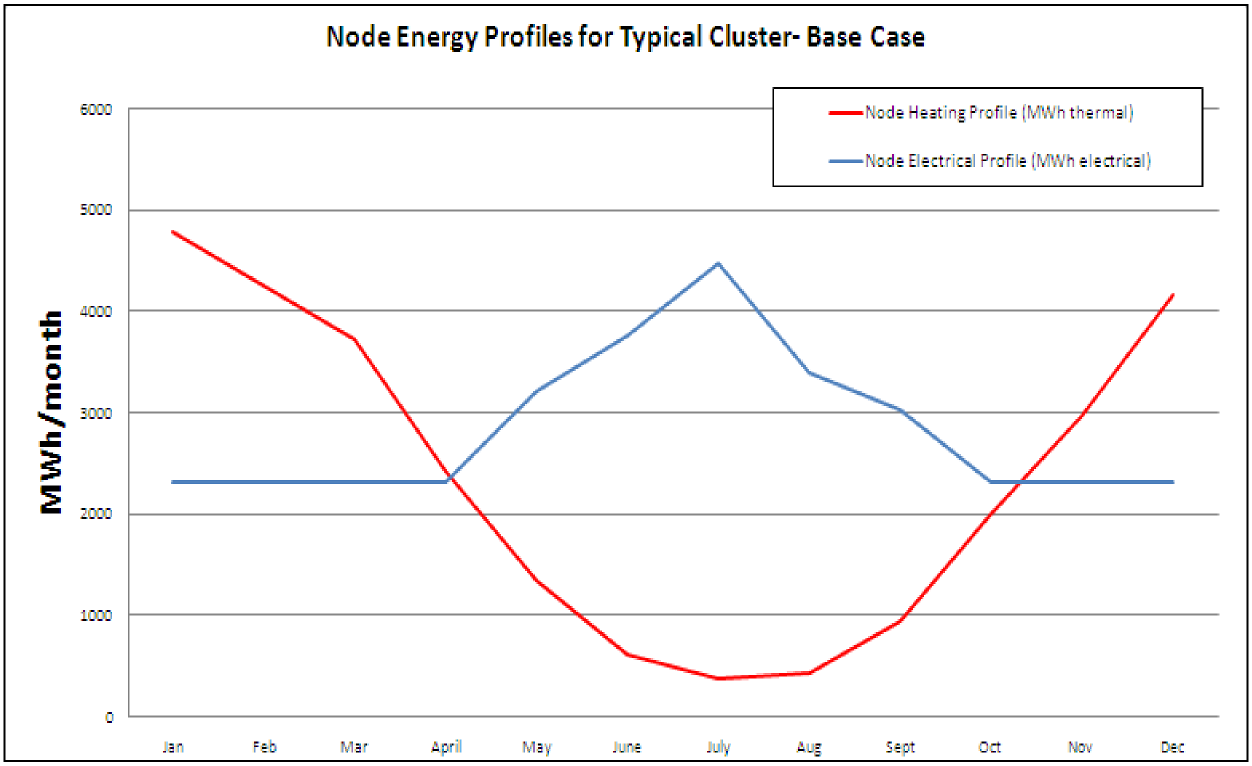
Tri-generation systems expand on CHP by utilizing recovered hot water/steam to power absorption chillers instead of electricity to produce the cooling effect. Modern absorption chillers feature double stage arrangement for increased performance (COP) and have almost no moving parts, making its maintenance less expensive. An example of this is contained within the Exhibition Place.

Use of heat for cooling is less efficient than conventional compression chillers from a Coefficient of Performance (COP) perspective, but a significant load displacement can be achieved when it is needed the most, i.e. in summer.

Node Energy Profile Assumptions

- Analysis of monthly energy levels to account for seasonal variations. Weekly and daily profiles are not considered at this stage
- Typical Building Cluster Composition
    - 50% New Building Tier 1 Commercial
    - 50% New Building Tier 1 Residential
- Node heating profile based on monthly degree-days (<18°C) for Toronto
- Node electrical profile based on base electrical load plus electricity required for space cooling; electric chiller COP is assumed at 2.7

Figure 5.4 Energy Demand Profiles for DES Node



Energy Supply Assumptions

- Base Load – Tri-generation system:
    - Technology: Gas Engine (GE Jenbacher J624 double-stage turbocharger or equivalent). This is a leading efficiency and environmental performance selection which may be doubled for larger developments and still comply with the 10 MWe threshold of the CESOP program.
        - Electrical Output: 4.4 MW electrical
        - Thermal Output: 4.1 MW thermal assuming production of hot water at 70/90°C
        - Electrical Efficiency: 46.5%
        - 2-stage absorption chiller (COP 1.25) sized to cover 40% of the cooling requirement
    - Operation: the gas engine operates in thermal load following to base thermal load during "on peak" hours (to maximize electricity sale revenue) It is assumed 15 hours per day and 5 days per week resulting in an annual average of 11 hours per day of operation
- Engine operation thermal load following to base thermal load
- Back up boilers are installed to supply heat for the mid and peak thermal loads
- Back up electric chillers are installed to supply cooling capacity the peak cooling load

The resulting supply and node energy profiles are shown in the following figures

Figure 5.5 Energy Demand Profiles for DES Node – Tri-generation

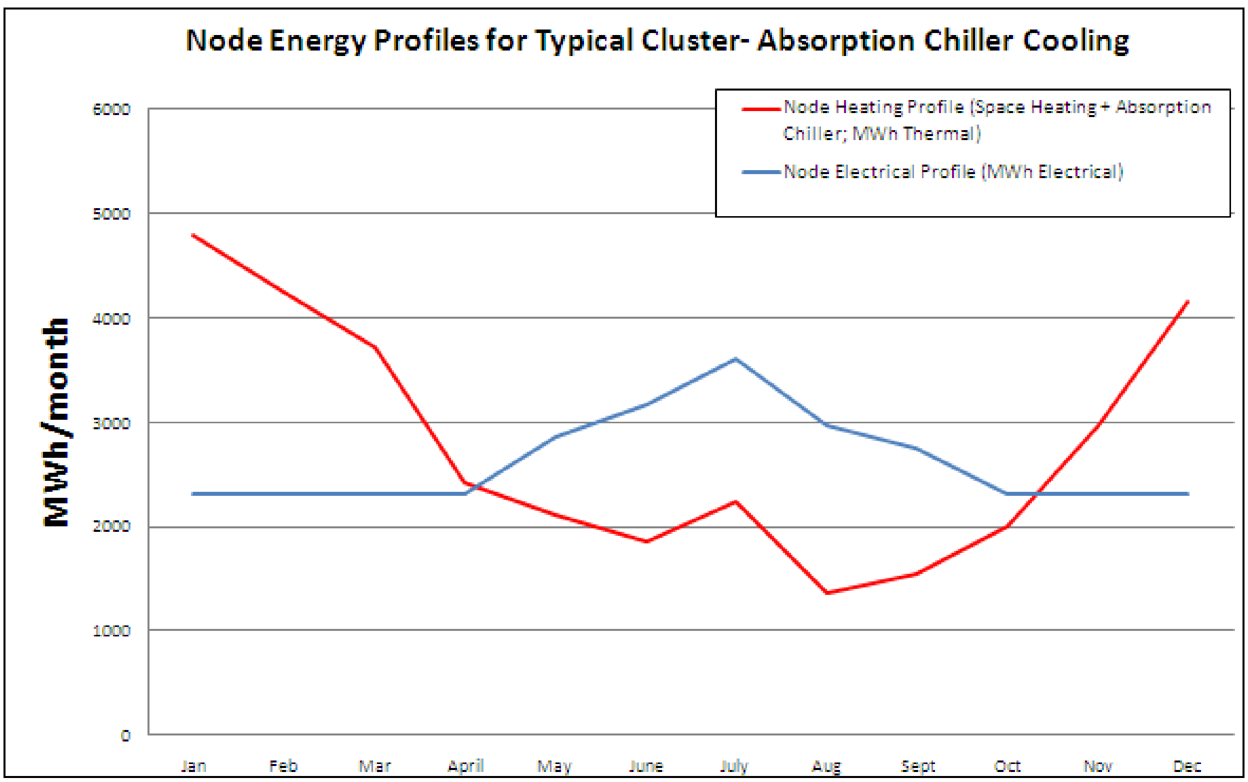


Figure 5.6 Thermal Profiles for DES Node – Tri-generation

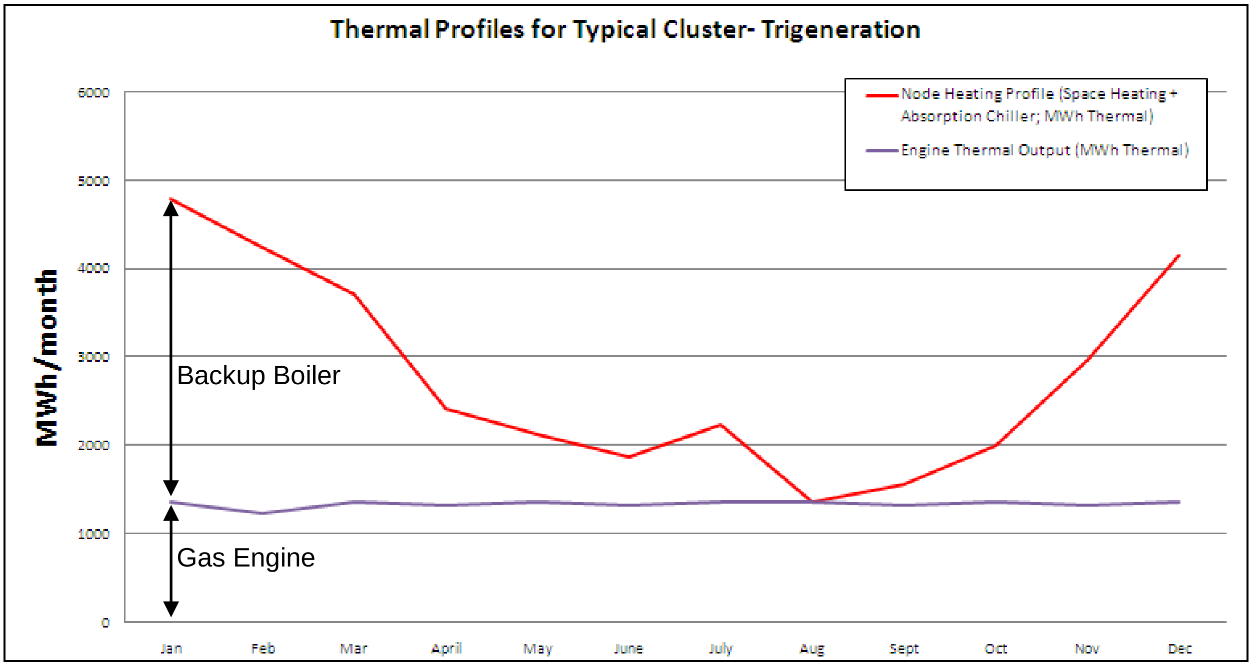


Figure 5.7 Electrical Profiles for DES Node – Tri-generation

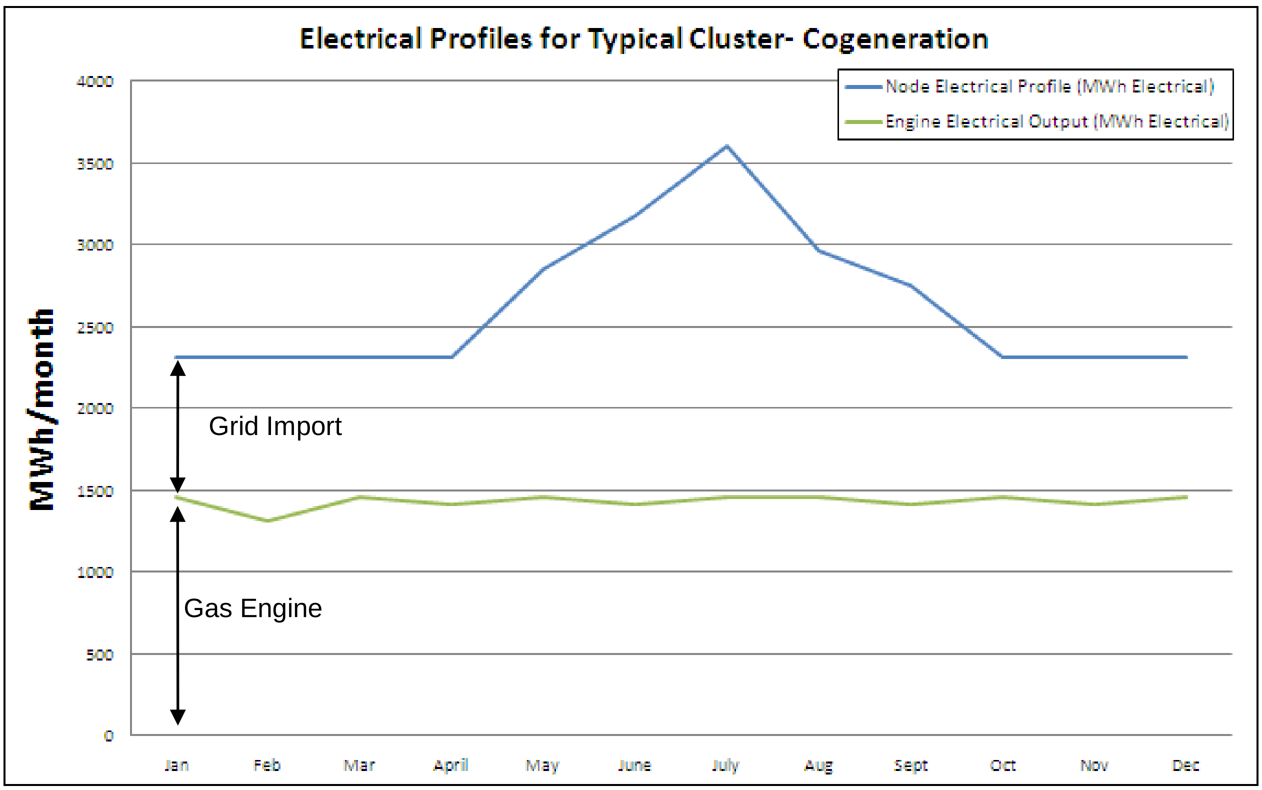


Table 5-3 DES Node - Performance Comparison – Base Case vs. Tri-generation

Base Case (Business As Usual)			TRIgeneration		
Annual Electricity Demand	MWh/year	34064	Annual Electricity Demand	MWh/year	14397
Transmission Loss[5]	%	6.56%	Transmission Loss[5]	%	6.56%
Annual Electricity Consumption	MWh/year	36456	Annual Electricity Consumption	MWh/year	15407
Emission Factor for Electricity[6]	$TonCO_2/MWh$	0.200	Emission Factor for Electricity[6]	$TonCO_2/MWh$	0.200
Annual GHG Emissions from Electricity	$TonCO_2/year$	7291	Annual GHG Emissions from Electricity	$TonCO_2/year$	3081
Annual Heat Demand	eMWh/year	27973	Annual Boiler Heat Demand	eMWh/year	17400
Boiler Seasonal Efficiency	%	65%	Boiler Seasonal Efficiency	%	80.0%
Annual Gas Consumption	eMWh/year	43036	Engine Electrical Efficiency	%	46.5%
Emission factor for Natural Gas[7]	$TonCO_2/MWh$	0.184	Annual Gas Consumption	eMWh/year	58653
			Emission factor for Natural Gas[7]	$TonCO_2/MWh$	0.184
Annual GHG Emissions from NG	$TonCO_2/year$	7919			
			Annual GHG Emissions from NG	$TonCO_2/year$	10792
Total GHG Emissions	$TonCO_2/year$	15210	Total GHG Emissions	$TonCO_2/year$	13874

NOTE:
5 - Canada National Average
6 - Value for the province of Ontario in 2007; Environment Canada, Canada's National Inventory Report: 1990-2008
7- Natural Resources Canada; http://oee.rncan.gc.ca/industrial/technical-info/benchmarking/ctwp/appendix-a.cfm?attr=5

Specific GHG Emission Reduction	**$kgCO_2/m^2$ .year**	**4.7**
GHG Emission Reduction	**$TonCO_2/year$**	**1336**
Relative GHG Emission Reduction	**%**	**8.78%**

Greenhouse Gas (GHG) Emissions

GHG emissions are calculated for the Business As Usual (BAU) case and for the Cogeneration district energy option in order to quantify emission reduction within the province of Ontario. For both calculations, the following assumptions are considered:

- A 6.56% loss factor is applied to the node annual electrical requirement to determine the electricity consumption seen at the electricity generator This factor represents Canada's National Average for both transmission and distribution losses
- Emission factor for electricity generation is assumed at 0.200 equivalent CO_2 tonne per MWh. This factor represents the Ontario average for year 2007 as specified by Environment Canada.
- Emission factor for natural gas combustion is assumed at 0.184 equivalent CO_2 tonne per MWh of heat as specified by Environment Canada
- Boiler seasonal efficiencies are assumed at 65% for individual boilers (BAU) and 80% for backup boiler

5.4.2 Summary and Discussion

As part of the cooling is provided by the absorption chiller, therefore part of the summer peak in electrical consumption is shifted to the thermal demand summer and shoulder seasons.

Assuming the tri-generation system is sized to provide the base thermal demand of the Node, the engine thermal output and building heat demand are set to match in the month of August. In this way the engine operation is optimized as the engine load is 100% constant.

Different load control strategy can also be implemented, but generally gas engine load should not drop below 50-60%.

The additional thermal load required on the other months is provided by efficient gas fired boilers which operate at a higher seasonal efficiency than single small unit. Also the fraction of cooling load not provided by the absorption chiller will be supplied by high-efficiency electrical chillers.

The engine is also generating electricity that displaces a fraction of the electricity imported from the grid. It is clear that the tri-generation system is able to cover a greater fraction of the cluster electrical demand compared to the conventional CHP solution.

Size of DES Node

The area of the DES node required for the assumptions made in this example is calculated as 286,906 m^2. If it is assumed that engine operation is viable down to 65% load, a larger fraction of the thermal load can be covered and the minimum size of the building cluster decreases to 186,552 m^2.

Greenhouse Gas Reductions

The proposed example shows a GHG emission reduction of 1,336 tonne of CO_2 per year (within the Province of Ontario), which represents a 8.8% reduction from the BAU scenario. Based on the size of the node, this GHG emission reduction corresponds to an annual reduction of 4.7 $kgCO_2/m^2$. This value is lower compared to the 8.3 $kgCO_2/m^2$ suggested by the Canadian District Energy Association because the tri-generation system covers only a fraction of the heating and cooling loads as shown in figure 5.6. In addition, emission factor for natural gas combustion and electricity adopted in the model is may differ from those used in other studies.

Energy Security

This initiative will embed 4.4 MWe within the City of Toronto resulting in a reduction of the Peak load strain on the incoming transmission infrastructure. Furthermore, during peak electrical loading of the summer, an additional 2507 MWh of additional electrical load may be displaced with absorption chillers.

6. Screening Matrix

Level 1 Screening

Table 6.1 is a preliminary Level 1 Screening Matrix which may assist the City of Toronto to review and prioritize potential developments for consideration to utilize DES technology. Some discussion of the evaluation methodology follows;

- It is stressed that Level 1 Screening is a desktop exercise which lacks specific site assessment (conceptual DES plant sizing /location and thermal distribution routing / obstructions)
- Highest points (10) are assigned to
  - Highest developed density – at this point, there is no de-rating of gross floor area relative to assumptions of secured connections versus remaining status quo
  - New development – it is assumed that the new developments will be contacted early enough by the City of Toronto to enable their facilities to be designed to enable interconnection to the DES
- At the level 1 screening, the breakout of commercial / institutional and multi residential is calculated in terms of the proportion of each and their associated rankings. However points are assigned only on the highest developed density ranking as follows
  - Rank 1 to 5 10 points
  - Rank 6 to 10 8 points
  - Rank 11 to 15 6 points
  - Rank 16 to 20 4 points
  - Rank 21 to 27 2 points
- Locations near existing DES are awarded points (5) on the assumption that they may be influenced to interconnect
- Locations near existing CHP (3rd party) are similarly awarded points (5) on the assumption that they may be influenced to develop a thermal distribution and connect users with appropriate economics
- Locations in the downtown core are awarded points on the basis
  - They could interconnect and utilize excess Deep Lake Cooling capacity (5 points) during evening hours (with thermal storage), and
  - Are most likely to be in a constrained electrical region (5 points) – pending Level 2 screening confirmation with Toronto Hydro
- Proximity to other considered DES nodes are identified and awarded points to recognize the economies of development scale for interconnection with opportunities to gain efficiencies in common staffing and reduced redundancy of major equipment at each site
- Existing "anchor" thermal loads (institutional, heavy industrial and light industrial) are awarded points on the basis that their loading is significant, consistent and differs from typical season space heating profile to "flatten" DES thermal load. Heavy industrial and institutional are awarded 5 points as they typically feature existing boilers while light industrial is awarded 3 points as they often feature direct natural gas fired rooftop equipment
- Multi-Residential are not assigned points from a thermal node perspective as they are featured within all 27 potential nodes

- GHG reductions are expected for all DES nodes (versus BAU) but can't be quantified or awarded points at Level 1 until the size of the DES /CHP opportunity may be better assessed together with the suitability and sizing of supplementary options including absorption chilling / thermal storage / geothermal and recovered heat from industrial/ data centre users

From the Level 1 Screening Matrix assessed for the 27 potential district energy nodes (see Appendix A), the following is the preliminary ranking

1.	Site 19	East Bay Front (Jarvis Street and Queens Quay)
2.	Site 15	Yonge Street and Dundas Street
3.	Site 16	Yonge Street and Bloor Street
4.	Site 25	West Don Lands (Eastern Avenue and Front Street)
5.	Site 24	Downsview Corporate Center (Sheppard Avenue and Allen Road)
6.	Site 27	Westwood Theatre Lands
7.	Site 17	Fort York (Bathurst Street and Lakeshore Boulevard).
8.	Site 26	Etobicoke Civic Complex (West Mall and Civic Center Court)
9.	Site 9 Site 13	Lawrence Phase 2 (Allen Road and Lawrence Road), and (tie) Kipling Avenue and Norseman Street
10.	Site 2 Site 3	Yonge Street and Sheppard Road, and (tie) Yonge Street and Empress Avenue

Level 2 Screening

The following Level 2 Screening are more intensive and can substantially modify the previous ranking and assumptions

1. It is not possible without in-depth discussions with Toronto Hydro (i.e. short circuit constraints, age and reliability of feeders, etc.) to identify Regions within the City of Toronto which are most electrically constrained and would benefit from embedded generation CHP.
2. Input from the Ministry of Environment relative to existing air quality performance for the nodes under consideration.
3. Input from existing identified cogeneration plants relative to their interest to expand thermal distribution systems and add 3rd party thermal users.
4. Input from existing industrial and data centre hosts relative to interest to install heat recovery equipment within their facility, develop distribution systems and add 3rd party thermal users
5. Available Physical space to develop a CHP and ability to develop a buried distribution system with minimal disruption to existing land use.
6. For existing developments, it is important to note how many units are to be considered and how many property owners and developers must sign a contract. Fewer and larger hosts are preferred
7. For existing developments, age of facility and age of building service equipment is important. Facilities older than 20 years are approaching re-investment of equipment according to their Asset Management Plans (AMPS) while facilities over 40 years may be approaching the end of the facilities expected occupancy range.

Table 6-1 Sample Level 1 Screening Matrix for District Energy

Potential DES Node Locations	Maximum Score	1: Yonge St & Eglinton Ave	2: Yonge St & Sheppard Ave	3: Yonge St & Empress Ave	4: McCowan Rd & Ellesmere Rd	5: Markham Rd & Hwy 401	6: Bessarion Rd (Leslie & Hwy 401)	7: Ellesmere Rd & Military Trail	8: Sheppard Ave E & Don Mills Rd	9: Eglinton Ave E & Don Mills Rd	10: Thorncliffe Park (Overlea Blvd)	11: Eglinton Ave & Pharmacy Ave	12: Bayview Ave & Lawrence Ave E	13: Kipling Ave & Norseman St
Diameter of node development (km)		1	1	1	1.5	1.5	1	1.5	1	1.5	1.5	1.5	1.5	1.5
Area of node (m^2)		785,000	785,000	785,000	1,766,250	1,766,250	785,000	1,766,250	785,000	1,766,250	1,766,250	1,766,250	1,766,250	1,766,250
Commercial / Institutional Component														
Gross Floor Area (x100,000 m^2)		6.00	5.00	3.00	7.00	1.00	7.00	4.00	5.00	7.00	2.00	4.00	9.00	13.00
RANK		8	9	18	3	23	3	13	9	3	21	13	2	1
% of total Node Development		46%	83%	50%	78%	50%	70%	80%	83%	88%	22%	80%	95%	99%
Developed density (floor area (m^2) / node area (m^2))		0.764	0.637	0.382	0.396	0.057	0.892	0.226	0.637	0.396	0.113	0.226	0.510	0.736
RANK		4	6	12	10	26	1	17	6	10	25	17	8	5
Multi-Residential Component														
Gross Floor Area (x100,000 m^2)		7.00	1.00	3.00	2.00	1.00	3.00	1.00	1.00	1.00	7.00	1.00	0.50	0.10
RANK		1	17	7	13	17	7	17	17	17	1	17	26	27
% of total Node Development		54%	17%	50%	22%	50%	30%	20%	17%	13%	78%	20%	5%	1%
Developed density (floor area (m^2) / node area (m^2))		0.892	0.127	0.382	0.113	0.057	0.382	0.057	0.127	0.057	0.396	0.057	0.028	0.006
RANK		2	15	6	18	20	6	20	15	20	5	20	26	27
Total Node Development														
Gross Floor Area (x100,000 m^2)		13.00	6.00	6.00	9.00	2.00	10.00	5.00	6.00	8.00	9.00	5.00	9.50	13.10
Developed density (floor area (m^2) / node area (m^2))		1.656	0.764	0.764	0.510	0.113	1.274	0.283	0.764	0.453	0.510	0.283	0.538	0.742
RANK		1	8	8	15	27	3	25	8	17	15	25	14	11
Score	**10**	**10**	**8**	**8**	**6**	**2**	**10**	**2**	**8**	**4**	**6**	**2**	**6**	**6**
Node Status (Maximum Score = 10)														
New vs. Existing Development		existing	existing	existing	existing	existing	existing	existing	existing	existing	existing	existing	existing	existing
Score	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Contains known existing CHP														
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Proximity to Existing DES														
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Proximity to Other Considered DES Node			near 3	near 2	near 5	near 4			near 23	near 10	near 9			near 27
Score	**5**	**0**	**5**	**5**	**5**	**5**	**0**	**0**	**5**	**5**	**5**	**0**	**0**	**5**
Electrical Load Considerations														
Suitable for CESOP CHP														
Score	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Proximity to Deep Lake Cooling														
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Within Downtown Core														
Score	**5**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Thermal Load Considerations														
Contains Institutional														
Score	**5**	**0**	**5**	**5**	**0**	**0**	**5**	**5**	**0**	**5**	**0**	**0**	**5**	**0**
Contains Light Industrial														
Score	**3**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**
Contains Heavy Industrial														
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
Renewable Energy Considerations														
Near Municipal Wastewater - biogas														
Score	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Scoring Summary														
Total Score	**68**	**20**	**23**	**23**	**19**	**12**	**20**	**12**	**18**	**19**	**16**	**7**	**16**	**24**
RANK		**15**	**11**	**11**	**17**	**24**	**15**	**24**	**19**	**17**	**20**	**27**	**20**	**9**

Potential DES Node Locations	14: Carlingview Dr & Dixon Rd	15: Yonge St & Dundas St	16: Yonge St & Bloor St	17: Fort York (Bathurst St & Lakeshore Blvd)	18: York University (Keele Campus)	19: EAST BAY FRONT (Jarvis St & Queens Quay)	20: LAWRENCE PHASE 2 (Allen Rd and Lawrence Ave)	21: Steeles Ave and Dufferin St	22: Eglinton Ave & Blackcreek Rd	23: Sheppard Ave & Victoria Park Ave	24: DOWNSVIEW CORPORATE CENTRE (Sheppard Ave & Allen Rd)	25: WEST DON LANDS (Eastern Ave & Front St)	26: Etobicoke Civic Complex (West Mall & Civic Centre Court)	27: Westwood Theatre Lands (Bloor St. W & Kipling Ave.)
Diameter of node development (km)	1.5	1	1	1	1.5	1	1.5	1.5	1.5	1.5	1	1	0.5	1
Area of node (m^2)	1,766,250	785,000	785,000	785,000	1,766,250	785,000	1,766,250	1,766,250	1,766,250	1,766,250	785,000	785,000	196,250	785,000
Commercial / Institutional Component														
Gross Floor Area (x100,000 m^2)	4.00	7.00	7.00	4.00	4.50	2.87	0.83	4.50	4.00	3.00	1.95	0.90	0.38	1.00
RANK	13	3	3	13	11	20	26	11	13	18	22	25	27	23
% of total Node Development	67%	78%	88%	62%	82%	31%	12%	86%	62%	43%	45%	17%	12%	36%
Developed density (floor area (m^2) / node area (m^2))	0.226	0.892	0.892	0.510	0.255	0.366	0.047	0.255	0.226	0.170	0.248	0.115	0.194	0.127
RANK	17	1	1	8	14	13	27	14	17	22	16	24	21	23
Multi-Residential Component														
Gross Floor Area (x100,000 m^2)	2.00	2.00	1.00	2.50	1.00	6.30	6.00	0.75	2.50	4.00	2.40	4.30	2.82	1.80
RANK	13	13	17	10	17	3	4	25	10	6	12	5	9	16
% of total Node Development	33%	22%	13%	38%	18%	69%	88%	14%	38%	57%	55%	83%	88%	64%
Developed density (floor area (m^2) / node area (m^2))	0.113	0.255	0.127	0.318	0.057	0.803	0.340	0.042	0.142	0.226	0.306	0.548	1.437	0.229
RANK	18	11	15	9	20	3	8	25	14	13	10	4	1	12
Total Node Development														
Gross Floor Area (x100,000 m^2)	6.00	9.00	8.00	6.50	5.50	9.17	6.83	5.25	6.50	7.00	4.35	5.20	3.20	2.80
Developed density (floor area (m^2) / node area (m^2))	0.340	1.146	1.019	0.828	0.311	1.168	0.387	0.297	0.368	0.396	0.554	0.662	1.631	0.357
RANK	22	5	6	7	23	4	19	24	20	18	13	12	2	21
Score	**2**	**10**	**8**	**8**	**2**	**10**	**4**	**2**	**4**	**4**	**6**	**6**	**10**	**2**
Node Status (Maximum Score = 10)														
New vs. Existing Development	existing	existing	existing	existing	existing	new	new	existing	existing	existing	new	new	new	new
Score	**0**	**0**	**0**	**0**	**0**	**10**	**10**	**0**	**0**	**0**	**10**	**10**	**10**	**10**
Contains known existing CHP	GTAA	U of T	U of T					Sanofi	former KODAK					
Score	**5**	**5**	**5**	**0**	**0**	**0**	**0**	**5**	**5**	**0**	**0**	**0**	**0**	**0**
Proximity to Existing DES		ENWAVE	U of T	ENWAVE		ENWAVE/ WTFT						ENWAVE/ WTFT		
Score	**0**	**5**	**5**	**5**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**
Proximity to Other Considered DES Node										near 8				near 13
Score	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**5**
Electrical Load Considerations														
Suitable for CESOP CHP														
Score	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Proximity to Deep Lake Cooling														
Score	**0**	**5**	**5**	**5**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Within Downtown Core														
Score	**0**	**5**	**5**	**5**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Thermal Load Considerations														
Contains Institutional														
Score	**5**	**5**	**5**	**0**	**5**	**0**	**5**	**5**	**0**	**0**	**5**	**5**	**0**	**0**
Contains Light Industrial														
Score	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**
Contains Heavy Industrial														
Score	**5**	**0**	**0**	**0**	**0**	**5**	**0**	**5**	**0**	**0**	**5**	**0**	**0**	**5**
Renewable Energy Considerations														
Near Municipal Wastewater - biogas														
Score	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**
Scoring Summary														
Total Score	**22**	**40**	**38**	**28**	**12**	**50**	**24**	**22**	**14**	**14**	**31**	**36**	**25**	**30**
RANK	**13**	**2**	**3**	**7**	**24**	**1**	**9**	**13**	**22**	**22**	**5**	**4**	**8**	**6**

7. Recommendations

The City of Toronto should continue to promote its role in the development of DES and review the preliminary screening matrix for contemplated future developments. Close attention to the impending OPA CESOP program and future greenhouse gas credits should also benefit the ROI of the contemplated DES relative to City of Toronto expectations.

As the BAU scenario will not satisfy any of the pillars of success for the project, City of Toronto may wish to review the merit of DES upon the differential cost between DES and BAU.

The City of Toronto should continue its promotion of Tier 1 and 2 standards to exert control over land use and development policies. In accordance with its current policies, The City of Toronto should consider "exerting influence" for interconnection into DES to ensure a rapid build out of the node to enhance efficiencies and achieve its success criteria. Beyond that, the system may revert to voluntary interconnection. By implementation of DES which score highest in the screening matrix, City of Toronto should be able to ensure initial DES development will be implemented with maximum success and be models for future DES development.

It is recommended that City of Toronto continue to move forward with DES as a proactive host as nearby communities including Markham, Guelph, Hamilton, Ottawa, London have – particularly relative to its unique energy security criteria. On this, GENIVAR recommend that City of Toronto pursue DES CHP (with further consideration of absorption chillers in the most electrically constrained nodes).

Appendix A

City of Toronto Potential Node Locations

District Energy Program Scan: Potential Node Locations