Appendix 1 - Model assumptions

	ACTION	IMPACT	MODELLING ASSUMPTIONS LC-MOD	MODELLING ASSUMPTIONS LC-AMB
			BUILDINGS	
			New buildings - building codes & standards	
1	Residential - New residential housing development targets net zero	Avoided thermal and electric energy	Scales up to 100% of new homes by 2030 for Part 9 residential under 5 units; Provincial target- strategy is to increase efficiency and remaining power is provided by solar PV. Applies to singles and doubles.	
2	Multi-res & Commercial - Passivehouse standard applied to multi-unit residential and commercial buildings	Avoided thermal and electric energy	Scales up to 100% of new multi res & commercial by 2030: Space Heat Demand < 15 kWh/m2/yr Primary energy demand < 120 kWh/m2/yr	
3	Renewable energy installation requirements or incentives on multi-res and commercial	Fuel-shifting; Local generation	Applies to new construction not covered by action #1; PV equals +/- 25% of total energy use	

	ACTION	IMPACT	MODELLING ASSUMPTIONS LC-MOD	MODELLING ASSUMPTIONS LC-AMB
	Existing buildings - retrofitting			
4	Retrofit homes prior to 1980	Avoided thermal and electric energy	Achieve thermal savings of 40%; electrical savings of 30%: scale up rate of retrofits exponentially beginning in 2020 so that all building stock pre 2016 is retrofit by 2050	
5	Retrofit homes after 1980	Avoided thermal and electric energy	Achieve thermal savings of 40%; electrical savings of 30%: scale up rate of retrofits exponentially beginning in 2020 so that all building stock pre 2016 is retrofit by 2050	
6	Retrofits in the institutional, commercial, and industrial (ICI) sector	Avoided thermal and electric energy	Achieve thermal savings of 40%; electrical savings of 30%: scale up rate of retrofits exponentially beginning in 2020 so that all building stock pre 2016 is retrofit by 2050	
7	Retrofits of multi-residential	Avoided thermal and electric energy	Retrofit all buildings of 5 storeys or more built between 1945 and 1984. Number of retrofits increases exponentially between 2020 and 2050; Achieve 50% savings of thermal energy; 40% of electricity. Fuel switch to geothermal.	
8	Re-commissioning of buildings	Avoided thermal and electric energy	15% savings (split between thermal and electrical)- 5% of commercial buildings and multi-unit residential buildings per year.	

	ACTION	IMPACT	MODELLING ASSUMPTIONS LC-MOD	MODELLING ASSUMPTIONS LC-AMB
9	Renovation threshold requirement to meet codes and standards	Avoided thermal and electric energy	Apply enhanced building code threshold starting in 2020 (beyond 2017 update) followed by 13% improvement on a five-year increment (Energy Conservation Report, 2016/2016, Chp 5, pg 93) 10% of renos to meet threshold/standard by 2021, 25% by 2026, 50% by 2031, 75% by 2036, 100% by 2050: Apply to 2.5% of buildings per year.	
	Renewable energy generation (on-site, building scale)			
10	Installation of heat pumps: air and ground source residential	Fuel-shifting; Local generation	Residential: Air source: scale up to 30% of the residential building stock by 2050; Ground source: scale up to 20% of the residential building stock by 2050.	Residential: Air source: scale up to 50% of the residential building stock by 2050: Ground source: scale up to 50% of the residential building stock by 2050.
11	Installation of heat pumps: air and ground source commercial	Fuel-shifting; Local generation	Commercial: Air source scale up to 40% of the building stock by 2050; Ground source: scale up to 25% of the building stock by 2050	Commercial: Air source: scale up to 50% of the building stock by 2050; Ground source: scale up to 35% of the building stock by 2050
12	Solar PV- net metering all existing buildings	Fuel-shifting; Local generation	30% of consumption for building electrical load for less than 5 storeys; 10% for multi-unit and commercial, adoption rate- scale up to 75% of buildings by 2050.	

	ACTION	IMPACT	MODELLING ASSUMPTIONS LC-MOD	MODELLING ASSUMPTIONS LC-AMB
13	Solar heating/hot water	Fuel-shifting; Local generation	Scale up to 40% of residential and 50% of commercial by 2050.	Residential: scale up to 60% of the building stock by 2050: Apply to 75% of the buildings hot water requirements. Commercial: scale up to 70% of the building stock by 2050. Apply to 100% of buildings hot water requirements.
	ENERGY GENERATION			
	Low or zero carbon energy generation (community scale)			
14	Solar PV - ground mount	Local energy generation	Install 2 MW per year between 2018 and 2050. (~240 ha in total)	
15	Switch district energy to renewable natural gas (RNG)	Fuel-shifting		Existing district energy system switches to RNG; geothermal (small fraction geothermal); small fraction biomass; 80% RNG, 10% geothermal, 10% biomass.
16	Energy storage	Fuel-shifting	Example of how a flywheel can displace a natural gas peaking plant with cost energy parameters: 20% capacity factor for flywheel storage as a backup: 10 MW by 2025; 100 MW by 2050	

	ACTION	IMPACT	MODELLING ASSUMPTIONS LC-MOD	MODELLING ASSUMPTIONS LC-AMB
17	Renewable natural gas	Fuel-shifting		Incrementally increase the % of renewable natural gas, so that by 2050 100% of required natural gas is displaced by renewable natural gas.
		TRANSPORT		
		Transit		
18	Electrify transit system	Fuel-shifting	Electrify GO & local buses; incrementally electrify buses starting in 2020; 100% electric fleet by 2040	
		Active		
19	Increase/improve cycling & walking infrastructure	Avoided transportation energy	Mode shift to 50% of the walking and cycling potential away from vehicles and driving. Use 2km for walking and 5km for cycling.	
20	Car free zones	Avoided transportation energy	Vehicular mode share in identified zones declines linearly from 2030 to 2050, reaching zero to and from those zones. Zones selection: by 2050, >150 people and jobs per hectare, roughly even split of people to jobs, close proximity to transit.	

	ACTION	IMPACT	MODELLING ASSUMPTIONS LC-MOD	MODELLING ASSUMPTIONS LC-AMB
	Private/personal use			
21	Electrify personal vehicles	Fuel-shifting	Only EVs sold after 2030, incremental increase to 2030. Include AV: ownership rate declines by 50% by 2050, VKT increases by 20% by 2050.	
22	Electrify commercial vehicles	Fuel-shifting	90% electric by 2050; incremental increase from 2020-2050.	

Appendix 2- Document review list

PLAN/POLICY			
City	**Region**	**Province/Federal**	**Utilities**
Markham Official Plan	York Region Growth Strategy	Green Energy Act - Ontario Regulation 397/11	
Greenprint	York Integrated Waste Management Master Plan	PPS	
CEPs for Secondary Plans	York Region Energy Management Action Plan	Cap & Trade	
Net zero ready buildings	York Region Greening Strategy	Ontario Building code	
Markham Climate Action Plan	York Region Corporate Air Quality Strategy	Ontario Climate Change Action Plan	
Corporate Energy Management Plan		Oak Ridges Moraine Conservation Act & Plan	
Markham Strategic Plan 2015-2019			
Markham's Cycling and Pathways Master Plan			
Economic Development Strategy			
Transportation Strategy			
Markham's Roadmap to 80% Diversion - Waste			
Zero Waste			
Sustainable Purchasing Practices Guide			
By-Law 105-95 - Outdoor Water Use			
Stormwater Management Strategy			
Tree Preservation By-law			

Bird Friendly Guidelines			
Markham Food Charter			

PROGRAM/PROJECT

City	Region	Province/Federal	Utilities
Markham Homegrown Community & Allotment Gardens	VIVANext Highway 7 expansion	Rouge National Urban Park	
EV charging station - Civic Centre	Smart Commute	Mission Innovation	
Battle of the Buildings	York Region Water for Tomorrow Program	"The Big Move" Regional Transportation Plan	
Bayview Glen SNAP	Youth On-Board		
Markham Solar Programs	YRT School Service		
Markham Energy Conservation Office (MECO)	YRT diesel-electric and bio-diesel pilot projects		
Markham District Energy	Alternative Energy initiatives		
Active & Safe Routes to School Program			
Markham Homegrown Workshops			
Staff E-learning			
Milk Bag Program			
Recycling Initiatives			
Stormwater Management Strategy			
Trees for Tomorrow			
Emerald Ash Borer			
Pollinators Initiative			
Markham Homegrown Seed Library & Enviropacks			
Paper Reduction			
Green Fleet Program			
LEED Silver for New Construction			
Pathways and trails master plan			

INCENTIVES/FUNDING

City	Region	Province/Federal	Utilities
Markham FIT (Feed-in Tariff)			Community Energy Conservation Program (CEC) - Enbridge

Markham Environmental Sustainability Fund			Save on Energy programs - Powerstream

Appendix 3- List of Actions

Table 35. Actions matrix for LC-mod and LC-amb modelling.

BUILDINGS		LC-MOD	LC-AMB
NEW BUILDINGS - BUILDINGS CODES & STANDARDS			
1	Residential - New residential housing development targets net zero	X	X
2	Multi-residential & Commercial - Passivehouse standard applied to multi-unit residential and commercial buildings	X	X
3	Renewable energy installation requirements or incentives on multi-res and commercial	X	X
EXISTING BUILDINGS - RETROFITTING			
4	Retrofit homes prior to 1980	X	X
5	Retrofit homes after 1980	X	X
6	Retrofits in ICI sector	X	X
7	Retrofits of multi-residential	X	X
8	Re-commissioning of buildings	X	X
9	Renovation threshold requirement to meet codes and standard	X	X
RENEWABLE ENERGY GENERATION (ON-SITE, BUILDING SCALE)			
10	Installation of heat pumps: air and ground source residential	X	X

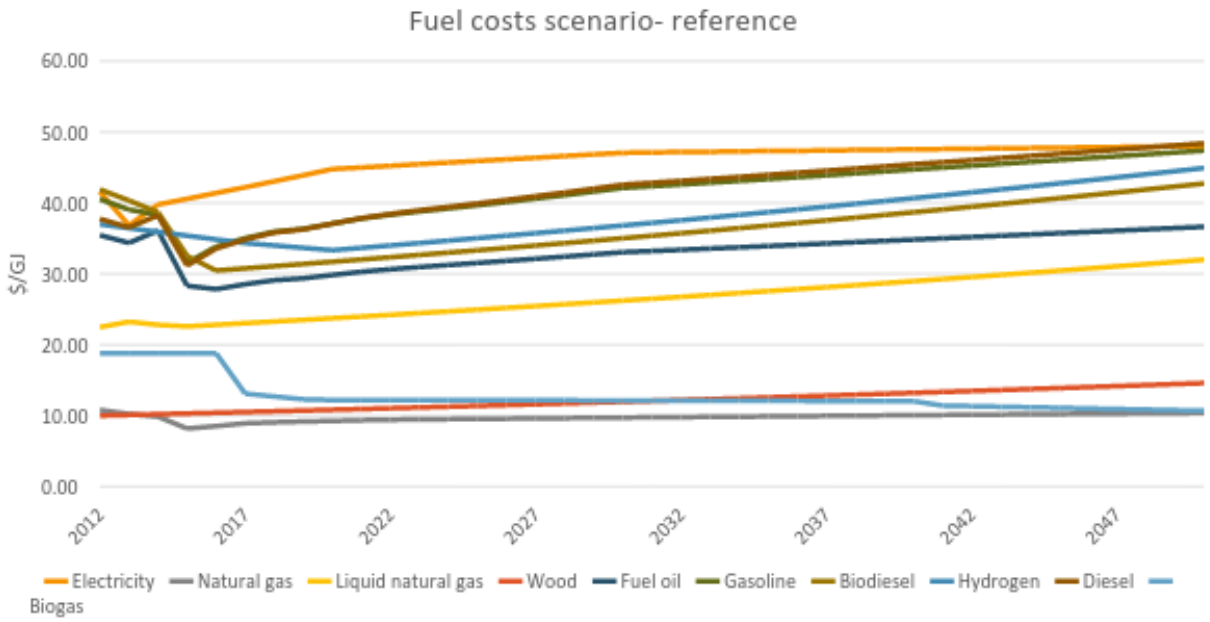
X	LC-mod assumption
X	LC-amb assumption (higher level of ambition than LC-mod)

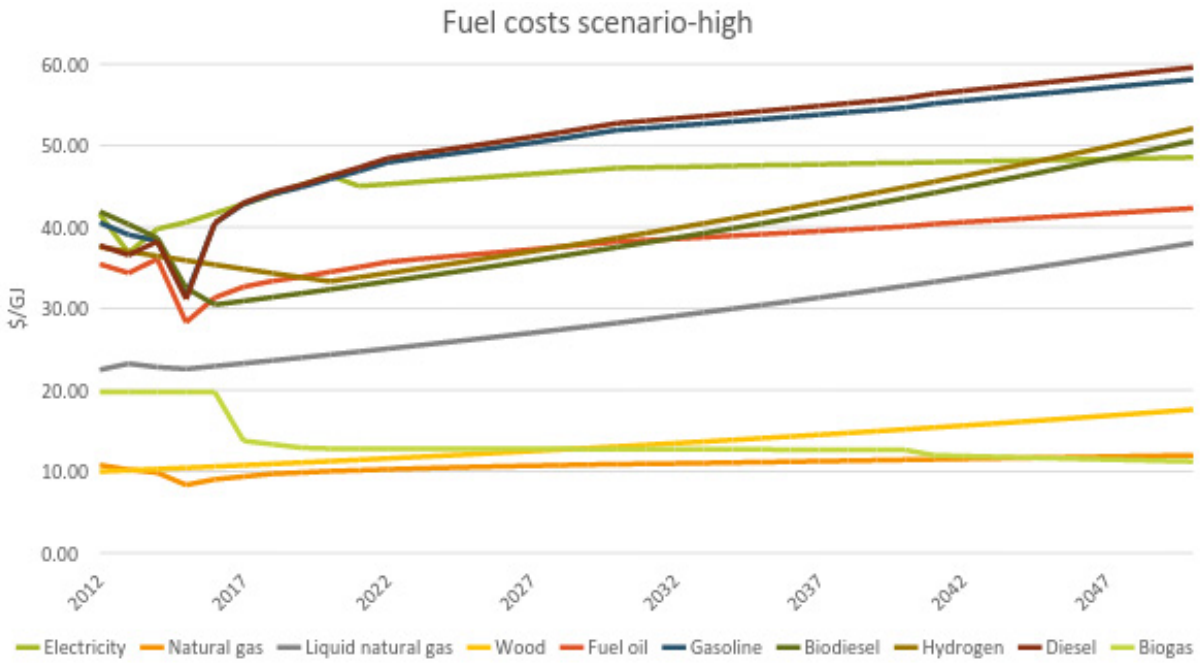
11	Installation of heat pumps: air and ground source commercial	X	X
12	Solar PV- net metering all existing buildings	X	X
13	Solar heating/hot water	X	X
ENERGY GENERATION			
Low or zero carbon energy generation (community scale)			
14	Solar PV - ground mount	X	X
15	Switch district energy to renewable natural gas		X
16	Energy storage	X	X
17	Renewable natural gas		X
TRANSPORT			
TRANSIT			
18	Electrify transit system	X	X
ACTIVE			
19	Increase/improve cycling & walking infrastructure	X	X
20	Car free zones	X	X
PRIVATE/PERSONAL USE			
21	Electrify personal vehicles	X	X
22	Electrify commercial vehicles	X	X

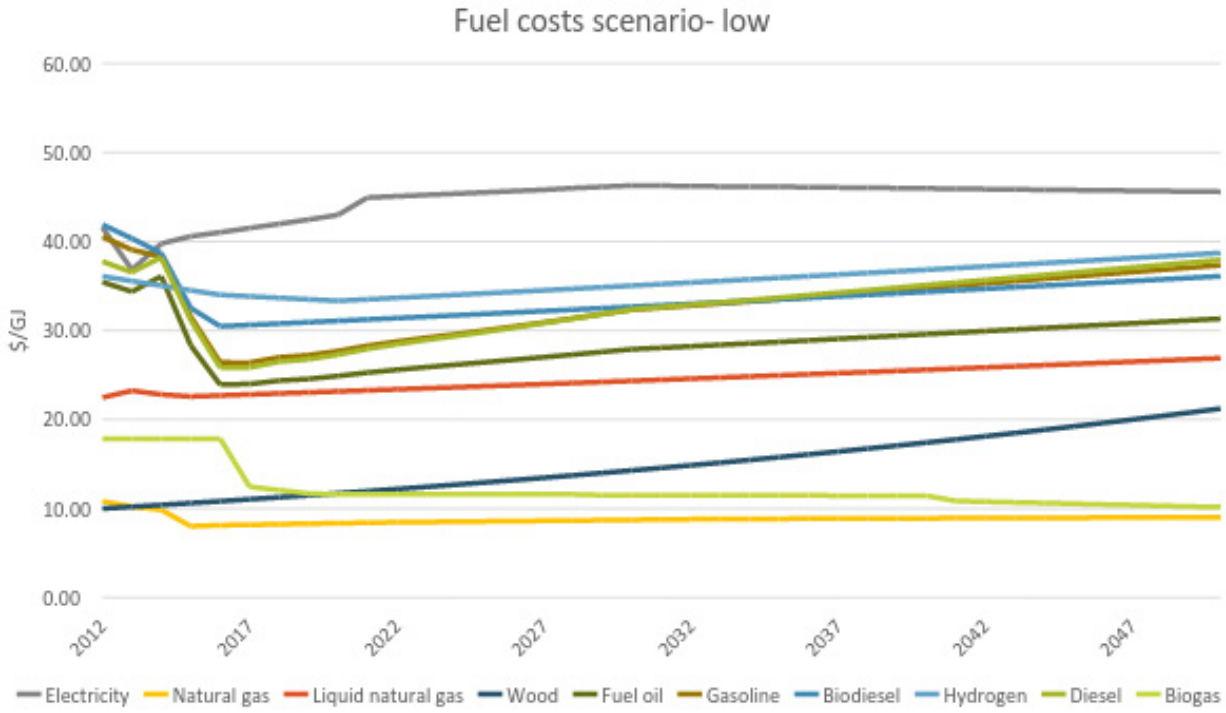
X	LC-mod assumption
X	LC-amb assumption (higher level of ambition than LC-mod)

Appendix 4- Energy cost projections

Energy cost projections were prepared based on projections from the National Energy Board's Energy Futures and the US Department of Energy.




Fuel costs scenario-high
60.00
50.00
40.00
30.00
20.00
10.00
0.00
$/GJ
2012
2017
2022
2027
2032
2037
2042
2047
Electricity
Natural gas
Liquid natural gas
Wood
Fuel oil
Gasoline
Biodiesel
Hydrogen
Diesel
Biogas


Fuel costs scenario- low
60.00
50.00
40.00
30.00
20.00
10.00
0.00
$/GJ
2012
2017
2022
2027
2032
2037
2042
2047
Electricity
Natural gas
Liquid natural gas
Wood
Fuel oil
Gasoline
Biodiesel
Hydrogen
Diesel
Biogas

Assumption/
Fuel type $/GJ ->

High	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Electricity	41.57	36.83	39.77	40.58	41.69	42.83	43.97	45.15	46.33	45.04	45.26	45.52	45.78
Natural gas	10.80	10.23	9.86	8.35	9.04	9.38	9.72	9.87	10.04	10.15	10.27	10.37	10.47
NGL	22.48	23.24	22.81	22.59	22.93	23.27	23.62	23.98	24.34	24.70	25.07	25.45	25.83
Wood	10.00	10.15	10.30	10.46	10.61	10.77	10.93	11.10	11.26	11.43	11.61	11.78	11.96
Kerosene and stove oil	35.45	34.37	36.09	28.31	31.35	32.66	33.37	33.88	34.49	35.07	35.70	36.04	36.34
Motor gasoline	40.54	39.06	38.32	31.56	40.49	42.84	44.05	44.89	45.89	46.86	47.93	48.44	48.89
Biodiesel	41.90	40.34	38.68	32.52	30.47	30.93	31.39	31.86	32.34	32.82	33.32	33.82	34.32
Ethanol	24.75	33.34	51.02	58.09	58.96	59.85	60.74	61.65	62.58	63.52	64.47	65.44	66.42
Methanol	24.75	33.34	51.02	58.09	58.96	59.85	60.74	61.65	62.58	63.52	64.47	65.44	66.42
Hydrogen	37.55	36.99	36.45	35.91	35.38	34.86	34.34	33.83	33.33	33.83	34.34	34.86	35.38
Diesel fuel oil	37.75	36.55	38.24	31.17	40.50	42.98	44.27	45.17	46.25	47.29	48.44	49.00	49.49
District energy	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50

Reference	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Electricity	41.57	36.83	39.77	40.58	41.40	42.21	43.05	43.90	44.78	45.00	45.23	45.48	45.70
Natural gas	10.80	10.23	9.86	8.18	8.52	8.92	9.06	9.17	9.26	9.36	9.42	9.48	9.51
NGL	22.48	23.24	22.81	22.59	22.82	23.04	23.27	23.51	23.74	23.98	24.22	24.46	24.71
Wood	10.00	10.10	10.20	10.30	10.41	10.51	10.62	10.72	10.83	10.94	11.05	11.16	11.27
Kerosene and stove oil	35.45	34.37	36.09	28.31	27.84	28.54	29.10	29.37	29.84	30.29	30.65	30.96	31.25
Motor gasoline	40.54	39.06	38.32	31.56	33.84	35.03	35.94	36.34	37.08	37.80	38.34	38.81	39.23
Biodiesel	41.90	40.34	38.68	32.52	30.47	30.77	31.08	31.39	31.71	32.02	32.34	32.67	32.99
Ethanol	24.75	33.34	51.02	58.09	58.96	59.55	60.15	60.75	61.36	61.97	62.59	63.21	63.85
Methanol	24.75	33.34	51.02	58.09	58.96	59.55	60.15	60.75	61.36	61.97	62.59	63.21	63.85
Hydrogen	37.00	36.45	35.91	35.38	34.86	34.34	34.00	33.67	33.33	33.67	34.00	34.34	34.69
Diesel fuel oil	37.75	36.55	38.24	31.17	33.57	34.84	35.83	36.27	37.08	37.86	38.45	38.97	39.44
District energy	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50

Low	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Electricity	41.57	36.83	39.77	40.58	41.03	41.51	41.98	42.46	42.98	44.93	45.08	45.23	45.37
Natural gas	10.80	10.23	9.86	8.01	8.13	8.18	8.24	8.30	8.35	8.41	8.46	8.49	8.52
NGL	22.48	23.24	22.81	22.59	22.70	22.82	22.93	23.05	23.16	23.28	23.39	23.51	23.63
Wood	10.00	10.20	10.40	10.61	10.82	11.04	11.26	11.49	11.72	11.95	12.19	12.43	12.68
Kerosene and stove oil	35.45	34.37	36.09	28.31	23.92	23.99	24.37	24.56	24.89	25.27	25.59	25.88	26.16
Motor gasoline	40.54	39.06	38.32	31.56	26.40	26.39	26.98	27.22	27.69	28.28	28.75	29.18	29.58
Biodiesel	41.90	40.34	38.68	32.52	30.47	30.62	30.78	30.93	31.08	31.24	31.40	31.55	31.71
Ethanol	24.75	33.34	51.02	58.09	58.38	58.67	58.97	59.26	59.56	59.85	60.15	60.45	60.76
Methanol	24.75	33.34	51.02	58.09	58.38	58.67	58.97	59.26	59.56	59.85	60.15	60.45	60.76
Hydrogen	36.09	35.56	35.03	34.52	34.01	33.84	33.67	33.50	33.33	33.50	33.67	33.84	34.01
Diesel fuel oil	37.75	36.55	38.24	31.17	25.82	25.85	26.50	26.77	27.29	27.94	28.46	28.94	29.39
District energy	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50

Assumption/
Fuel type $/GJ ->

High	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
Electricity	46.00	46.26	46.51	46.74	46.99	47.25	47.32	47.36	47.43	47.51	47.58	47.62	47.69
Natural gas	10.56	10.64	10.71	10.78	10.85	10.90	10.95	10.99	11.04	11.10	11.15	11.21	11.27
NGL	26.22	26.61	27.01	27.41	27.83	28.24	28.67	29.10	29.53	29.98	30.43	30.88	31.35
Wood	12.14	12.32	12.50	12.69	12.88	13.07	13.27	13.47	13.67	13.88	14.08	14.30	14.51
Kerosene and stove oil	36.64	36.94	37.25	37.56	37.88	38.21	38.38	38.56	38.74	38.93	39.12	39.31	39.50
Motor gasoline	49.35	49.83	50.33	50.83	51.37	51.90	52.15	52.42	52.68	52.95	53.22	53.51	53.79
Biodiesel	34.84	35.36	35.89	36.43	36.98	37.53	38.09	38.67	39.25	39.83	40.43	41.04	41.65
Ethanol	67.42	68.43	69.45	70.50	71.55	72.63	73.72	74.82	75.94	77.08	78.24	79.41	80.60
Methanol	67.42	68.43	69.45	70.50	71.55	72.63	73.72	74.82	75.94	77.08	78.24	79.41	80.60
Hydrogen	35.91	36.45	36.99	37.55	38.11	38.68	39.26	39.85	40.45	41.06	41.67	42.30	42.93
Diesel fuel oil	50.00	50.53	51.06	51.61	52.18	52.75	53.03	53.33	53.62	53.92	54.23	54.54	54.86
District energy	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	11.55	11.55

Reference	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
Electricity	45.93	46.15	46.37	46.62	46.85	47.07	47.14	47.18	47.21	47.29	47.32	47.36	47.40
Natural gas	9.55	9.58	9.62	9.65	9.69	9.72	9.75	9.79	9.82	9.86	9.89	9.92	9.96
NGL	24.95	25.20	25.45	25.71	25.97	26.23	26.49	26.75	27.02	27.29	27.56	27.84	28.12
Wood	11.38	11.49	11.61	11.73	11.84	11.96	12.08	12.20	12.32	12.45	12.57	12.70	12.82
Kerosene and stove oil	31.54	31.83	32.13	32.43	32.74	33.05	33.22	33.39	33.57	33.74	33.92	34.10	34.28
Motor gasoline	39.68	40.14	40.62	41.10	41.61	42.12	42.36	42.61	42.86	43.11	43.37	43.63	43.90
Biodiesel	33.32	33.66	33.99	34.33	34.68	35.02	35.37	35.73	36.09	36.45	36.81	37.18	37.55
Ethanol	64.49	65.13	65.78	66.44	67.10	67.77	68.45	69.14	69.83	70.53	71.23	71.94	72.66
Methanol	64.49	65.13	65.78	66.44	67.10	67.77	68.45	69.14	69.83	70.53	71.23	71.94	72.66
Hydrogen	35.03	35.38	35.74	36.10	36.46	36.82	37.19	37.56	37.94	38.32	38.70	39.09	39.48
Diesel fuel oil	39.93	40.43	40.95	41.47	42.02	42.57	42.84	43.11	43.39	43.67	43.96	44.26	44.55
District energy	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	11.55	11.55

Low	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
Electricity	45.52	45.67	45.81	46.00	46.15	46.29	46.26	46.22	46.18	46.15	46.15	46.11	46.07
Natural gas	8.56	8.59	8.63	8.66	8.69	8.73	8.76	8.80	8.82	8.84	8.85	8.87	8.88
NGL	23.75	23.86	23.98	24.10	24.22	24.34	24.47	24.59	24.71	24.84	24.96	25.08	25.21
Wood	12.94	13.19	13.46	13.73	14.00	14.28	14.57	14.86	15.16	15.46	15.77	16.08	16.41
Kerosene and stove oil	26.44	26.72	27.01	27.30	27.60	27.90	28.06	28.22	28.39	28.55	28.72	28.89	29.07
Motor gasoline	30.01	30.45	30.90	31.37	31.85	32.34	32.57	32.80	33.03	33.27	33.51	33.76	34.01
Biodiesel	31.87	32.03	32.19	32.35	32.51	32.67	32.84	33.00	33.17	33.33	33.50	33.67	33.83
Ethanol	61.06	61.37	61.67	61.98	62.29	62.60	62.92	63.23	63.55	63.86	64.18	64.50	64.83
Methanol	61.06	61.37	61.67	61.98	62.29	62.60	62.92	63.23	63.55	63.86	64.18	64.50	64.83
Hydrogen	34.18	34.35	34.52	34.69	34.86	35.04	35.21	35.39	35.57	35.74	35.92	36.10	36.28
Diesel fuel oil	29.85	30.33	30.83	31.33	31.86	32.39	32.64	32.90	33.16	33.42	33.69	33.97	34.25
District energy	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	11.55	11.55

Assumption/
Fuel type $/GJ ->

High	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Electricity	47.77	47.84	47.88	47.96	48.03	48.09	48.16	48.22	48.29	48.35	48.42	48.48	48.55
Natural gas	11.32	11.38	11.44	11.49	11.55	11.61	11.66	11.72	11.77	11.83	11.89	11.94	12.00
NGL	31.82	32.29	32.78	33.27	33.77	34.27	34.79	35.31	35.84	36.38	36.92	37.48	38.04
Wood	14.73	14.95	15.17	15.40	15.63	15.87	16.10	16.34	16.59	16.84	17.09	17.35	17.61
Kerosene and stove oil	39.69	39.88	40.07	40.38	40.60	40.81	41.02	41.24	41.45	41.67	41.88	42.09	42.31
Motor gasoline	54.09	54.37	54.67	55.16	55.48	55.81	56.14	56.47	56.79	57.12	57.45	57.77	58.10
Biodiesel	42.28	42.91	43.56	44.21	44.87	45.55	46.23	46.92	47.63	48.34	49.07	49.80	50.55
Ethanol	81.81	83.04	84.29	85.55	86.83	88.14	89.46	90.80	92.16	93.54	94.95	96.37	97.82
Methanol	81.81	83.04	84.29	85.55	86.83	88.14	89.46	90.80	92.16	93.54	94.95	96.37	97.82
Hydrogen	43.58	44.23	44.90	45.57	46.25	46.95	47.65	48.36	49.09	49.83	50.57	51.33	52.10
Diesel fuel oil	55.18	55.49	55.82	56.35	56.71	57.07	57.43	57.79	58.14	58.50	58.86	59.22	59.58
District energy	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55

Reference	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Electricity	47.47	47.51	47.55	47.60	47.65	47.70	47.75	47.79	47.84	47.89	47.94	47.98	48.03
Natural gas	9.99	10.03	10.06	10.10	10.13	10.17	10.20	10.23	10.27	10.30	10.34	10.37	10.41
NGL	28.40	28.68	28.97	29.26	29.55	29.85	30.15	30.45	30.75	31.06	31.37	31.68	32.00
Wood	12.95	13.08	13.21	13.35	13.48	13.61	13.75	13.89	14.03	14.17	14.31	14.45	14.60
Kerosene and stove oil	34.47	34.65	34.83	35.01	35.19	35.37	35.55	35.73	35.91	36.10	36.28	36.46	36.64
Motor gasoline	44.18	44.45	44.73	44.98	45.25	45.52	45.79	46.05	46.32	46.59	46.86	47.13	47.39
Biodiesel	37.93	38.31	38.69	39.08	39.47	39.86	40.26	40.66	41.07	41.48	41.89	42.31	42.74
Ethanol	73.39	74.12	74.87	75.61	76.37	77.13	77.91	78.68	79.47	80.27	81.07	81.88	82.70
Methanol	73.39	74.12	74.87	75.61	76.37	77.13	77.91	78.68	79.47	80.27	81.07	81.88	82.70
Hydrogen	39.87	40.27	40.67	41.08	41.49	41.91	42.32	42.75	43.18	43.61	44.04	44.48	44.93
Diesel fuel oil	44.85	45.15	45.46	45.74	46.04	46.33	46.63	46.93	47.22	47.52	47.81	48.11	48.41
District energy	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55

Low	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Electricity	46.04	46.00	45.96	45.93	45.89	45.85	45.81	45.78	45.74	45.70	45.67	45.63	45.59
Natural gas	8.89	8.90	8.91	8.92	8.93	8.95	8.96	8.97	8.98	8.99	9.00	9.01	9.03
NGL	25.34	25.46	25.59	25.72	25.85	25.98	26.11	26.24	26.37	26.50	26.63	26.76	26.90
Wood	16.73	17.07	17.41	17.76	18.11	18.48	18.85	19.22	19.61	20.00	20.40	20.81	21.22
Kerosene and stove oil	29.24	29.41	29.59	29.76	29.94	30.11	30.28	30.46	30.63	30.80	30.98	31.15	31.32
Motor gasoline	34.27	34.52	34.79	35.04	35.29	35.55	35.80	36.06	36.31	36.57	36.83	37.08	37.34
Biodiesel	34.00	34.17	34.34	34.52	34.69	34.86	35.04	35.21	35.39	35.56	35.74	35.92	36.10
Ethanol	65.15	65.48	65.80	66.13	66.46	66.80	67.13	67.47	67.80	68.14	68.48	68.83	69.17
Methanol	65.15	65.48	65.80	66.13	66.46	66.80	67.13	67.47	67.80	68.14	68.48	68.83	69.17
Hydrogen	36.46	36.65	36.83	37.01	37.20	37.39	37.57	37.76	37.95	38.14	38.33	38.52	38.71
Diesel fuel oil	34.53	34.81	35.11	35.38	35.67	35.95	36.23	36.51	36.80	37.08	37.36	37.65	37.93
District energy	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55

Assumption/
Fuel type $/GJ ->

High	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Electricity	48.62	48.68	48.75	48.81	48.88	48.94	49.01	49.08	49.14	49.21	49.27
Natural gas	12.06	12.11	12.17	12.23	12.28	12.34	12.39	12.45	12.51	12.56	12.62
NGL	38.61	39.19	39.78	40.37	40.98	41.59	42.22	42.85	43.49	44.15	44.81
Wood	17.87	18.14	18.41	18.69	18.97	19.25	19.54	19.84	20.13	20.43	20.74
Kerosene and stove oil	42.52	42.74	42.95	43.17	43.38	43.59	43.81	44.02	44.24	44.45	44.67
Motor gasoline	58.43	58.76	59.08	59.41	59.74	60.06	60.39	60.72	61.05	61.37	61.70
Biodiesel	51.31	52.08	52.86	53.65	54.46	55.27	56.10	56.94	57.80	58.66	59.54
Ethanol	99.28	100.77	102.28	103.82	105.38	106.96	108.56	110.19	111.84	113.52	115.22
Methanol	99.28	100.77	102.28	103.82	105.38	106.96	108.56	110.19	111.84	113.52	115.22
Hydrogen	52.88	53.68	54.48	55.30	56.13	56.97	57.83	58.69	59.57	60.47	61.37
Diesel fuel oil	59.94	60.30	60.66	61.02	61.38	61.74	62.09	62.45	62.81	63.17	63.53
District energy	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55

Reference	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Electricity	48.08	48.13	48.17	48.22	48.27	48.32	48.37	48.41	48.46	48.51	48.56
Natural gas	10.44	10.48	10.51	10.55	10.58	10.61	10.65	10.68	10.72	10.75	10.79
NGL	32.32	32.64	32.97	33.30	33.63	33.97	34.31	34.65	35.00	35.35	35.70
Wood	14.74	14.89	15.04	15.19	15.34	15.49	15.65	15.80	15.96	16.12	16.28
Kerosene and stove oil	36.82	37.00	37.18	37.36	37.54	37.72	37.90	38.09	38.27	38.45	38.63
Motor gasoline	47.66	47.93	48.20	48.46	48.73	49.00	49.27	49.54	49.80	50.07	50.34
Biodiesel	43.16	43.60	44.03	44.47	44.92	45.37	45.82	46.28	46.74	47.21	47.68
Ethanol	83.52	84.36	85.20	86.06	86.92	87.79	88.66	89.55	90.45	91.35	92.26
Methanol	83.52	84.36	85.20	86.06	86.92	87.79	88.66	89.55	90.45	91.35	92.26
Hydrogen	45.38	45.83	46.29	46.75	47.22	47.69	48.17	48.65	49.14	49.63	50.13
Diesel fuel oil	48.70	49.00	49.29	49.59	49.88	50.18	50.48	50.77	51.07	51.36	51.66
District energy	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55

Low	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**
Electricity	45.56	45.52	45.48	45.44	45.41	45.37	45.33	45.30	45.26	45.22	45.19
Natural gas	9.04	9.05	9.06	9.07	9.08	9.09	9.11	9.12	9.13	9.14	9.15
NGL	27.03	27.17	27.30	27.44	27.58	27.72	27.85	27.99	28.13	28.27	28.42
Wood	21.65	22.08	22.52	22.97	23.43	23.90	24.38	24.87	25.36	25.87	26.39
Kerosene and stove oil	31.50	31.67	31.85	32.02	32.19	32.37	32.54	32.71	32.89	33.06	33.24
Motor gasoline	37.59	37.85	38.10	38.36	38.61	38.87	39.12	39.38	39.64	39.89	40.15
Biodiesel	36.28	36.46	36.65	36.83	37.01	37.20	37.38	37.57	37.76	37.95	38.14
Ethanol	69.52	69.86	70.21	70.56	70.92	71.27	71.63	71.99	72.34	72.71	73.07
Methanol	69.52	69.86	70.21	70.56	70.92	71.27	71.63	71.99	72.34	72.71	73.07
Hydrogen	38.91	39.10	39.30	39.49	39.69	39.89	40.09	40.29	40.49	40.69	40.90
Diesel fuel oil	38.21	38.49	38.78	39.06	39.34	39.63	39.91	40.19	40.47	40.76	41.04
District energy	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55	11.55

Fuel	Source
Electricity	1
Natural gas	1
NGL	3
Wood	
Kerosene and stove oil	1
Motor gasoline	1
Biodiesel	2
Ethanol	2
Methanol	3
Hydrogen	4
Diesel fuel oil	1
District energy	

Key

1 National Energy Board Energy Futures

2 Clean Cities Alternative Fuel report

3 General assumption

4 https://energy.gov/sites/prod/files/2015/06/f23/fcto_myrdd_production.pdf

Appendix 5- Acronyms and Glossary

ACRONYMS

BAU	Business-As-Usual
CAFE	Corporate Average Fuel Economy
CANSIM	Canadian Socio-Economic Information Management System
CHP	Combined heat and power
CO_2e	Carbon dioxide equivalents
GJ	Gigajoule; one billion joules; one gigajoule is equivalent to about 30 litres of gasoline
GPC	Global Protocol for Cities
HVAC	Heating, ventilation and cooling
ICE	Internal combustion engine
IESO	Independent Electricity System Operator
LIC	Local improvement charge
LPG	Liquefied Petroleum Gas
MJ	Mega Joule
NEB	National Energy Board
NIR	National Inventory Report
NPV	Net present value
PIHB	Plug in hybrid
PJ	Petajoule
PV	photovoltaic
RESD	Report on Energy Supply and Demand
RNG	Renewable Natural Gas
TJ	Tera Joule
VKT	Vehicle Kilometers Travelled

Glossary

TERM	DEFINITION
Business as usual (BAU)	A scenario that illustrates energy use and GHG emissions if no additional policies, actions or strategies are implemented.
Capital investment	Funds invested in fixed assets. Also known as CAPEX.
Carbon price	A representation of the cost of carbon as a result of the introduction of cap and trade in Ontario or carbon pricing by the Federal Government.
Cohort-survival population model	A means of determining population totals over time, using estimated survival rates for each age group, as defined by the model, and a defined birth rate.
Constant dollars	Adjusted value of currency so that future expenditures are represented in 2017 dollars using a discounting rate of 3%.
Cumulative investment	The sum of annual investments added up over a defined period of years. For example, the cumulative investment from 2017 to 2020 is the sum of the investments in each of those years. Can be represented in either constant or current dollars.
Current dollars	Un-adjusted value of currency; future dollars are not adjusted. Also known as the nominal dollar value.
Discount rate	A rate that converts current dollars to constant dollars, indicating that future dollars are worth less than current dollars. For this analysis a discount rate of 3% was used.
Energy demand	The total amount of energy that is being drawn by users in a given area at a given time.
Energy expenditures	Money spent on fuel.
Energy supply	The total amount of energy being produced and delivered to consumers at a given time.
Flywheel	A heavy wheel used to store and stabilize rotational energy in the machine within which it revolves.
Low carbon moderate (LC-mod)	A scenario that includes 22 actions to achieve significant GHG emissions reductions for the City of Markham. Total remaining emissions in 2015 are 0.5 $MtCO_2e$ (68% reduction over 2011).

TERM	DEFINITION
Low carbon ambitious (LC-amb)	A scenario that builds upon the moderate scenario with a set of more ambitious assumptions, which focus on increasing the deployment of solar heating/hot water and air and ground source heat pumps in the residential and commercial sectors to reduce consumption of natural gas for heating. Total remaining emissions in 2015 are 0.16 $MtCO_2e$ (90% reduction over 2011).
Net present value (NPV)	The value in the present of a sum of money, in contrast to some future value it will have when it has been invested at compound interest. A discounting rate of 3% was applied.
Net zero emissions	A net zero energy emissions Markham is one that has greatly reduced energy needs through efficiency gains and conservation. Annual energy needs for vehicles, thermal, and electricity are met by sustainable and non-fossil fuel sources, carbon offsets and/or carbon sequestration (where feasible within Markham) resulting in an annual net zero balance of greenhouse gas emissions.
Operating expenditures	Operating expenses include maintenance expenditures, energy expenditures and carbon price expenditures. Also known as OPEX.
Person-years of employment	A person-year is defined as the amount of work done by an individual during a working year, on a specific job.
Total expenditures	Total expenditures include capital investments and operating expenses.

Appendix 6 - SWG Recommendations

Markham Municipal Energy Plan Stakeholder Working Group Meeting #9
Brainstorming Session for MEP Recommendations
July 12, 2017

Residential – Existing

Consumer centered digital platform

- An interactive, user-friendly, accessible consumer focused digital platform
- Provides free home energy assessment services, engaging educational tools, targeted messaging and content on how to embed energy efficiency products and services in home renovations
- Examples: Mass Save – Online home Energy Assessment and Rise

Communication Platform

- Sharing positive energy saving project experiences with other homeowners
- Current influx in home renovations could foster energy improvements
- City of Markham can potentially publish a list of qualified home improvement contractors who meet the standard ability to deliver home improvements that also reduce energy use
- Example: York Region has a program for publicizing qualified irrigation contractors who have received training in water savings
- Buyer's Group Platform: connecting local buyers' groups with suppliers of energy efficient products and services to empower homeowners through collective buying or sharing of information and experiences

Additional Ideas

- Increase homeowner awareness, motivation and involvement in order to make substantial impact in reducing energy consumption in existing buildings
- Ensure that the appropriate action list from SSG are addressed in developing plans regarding the above two items
- Information on existing rebate programs need to be made available and publicized to existing homeowners (i.e. IESO platform that is in the works)

Residential – New

- Continuous information, education and engagement of the public in general, and new construction stakeholders and prospective customers specifically, on new technologies, or arrival of these technologies in the market
- Encourage and support utilities to promote voluntary stretch codes via incentive programs to encourage early adoption of energy efficiency before it becomes "codified". Early adopters and leaders should be continually encouraged and recognized. Incentives such as reduced development charges could be considered, with rationale explained clearly to developers
- Reach out and provide opportunities to builder-developers to participate in new technology pilot programs
- Continue exploring new technologies through demonstration projects to increase broad adoption
- Commercialization, adoption and wider proliferation of new energy efficient and low carbon technologies leads to eventual cost reductions to bring such technologies to the market. This will reduce the incremental cost barriers to building energy efficiency homes
- Increase incentives for builders and developers to build energy efficient homes above the building code

Transportation

Commercial Vehicles

- Scope alternative fuel sources, not sure if electrifying these vehicles as listed in SSG's actions is feasible especially for heavy trucks
- Recommend evaluating truck operations on alternative fuels such as propane, renewable natural gas or compressed natural gas. Also get NOx, PM2.5 and PM10 benefits.
- Discuss this with local transportation companies
- Scope a fueling station in Markham based on EnerCan road map
- Apply for the FCM Green Transportation application to examine the business proposition of converting municipal medium to heavy commercial fleet to alternative fuels

Personal Vehicles

- Electrify personal vehicles as recommended by SSG
- Engage with Plug n' Drive to educate consumers
- Engage QUEST Ontario group

Public Transit

- Electrify rapid transit per Metrolinx plan as recommended by SSG (seek funding to implement this)
- Look at getting conventional public transit early in new neighbourhoods and increase service within established neighbourhoods, especially the "last mile" problem
- Seek FCM green transportation funding to develop pilot proposals and partially fund capital projects
- Pursue transportation pilots such as:
    - increasing shuttle bus service to GO train stations to complement the increased service recently initiated and alleviate parking issues
    - Try free transit or no-fare zones as a pilot
    - Continue to track York Region Transit interest in hydrogen vehicles

Active Transportation

- Increase and improve active transportation infrastructure as recommended by SSG
- Seek funding opportunities to increase active transportation initiatives (i.e. CycleON)
- Update Markham Masterplan for active transportation infrastructure

Car-Free Zones

- As recommended by SSG, this creates a culture of transit and active transportation which aligns with the priorities in the Greenprint
- Continue to use land use planning principles to create communities that are more transit and active transportation friendly

ICI Sector (Industrial, Commercial and Institutional)

Accelerating Energy Emissions Descent in the City of Markham

- Technologies exist already today that can drastically energy consumption in both new construction and existing buildings
- Partner with early adopters to lead and share their best practices and lessons learned in reducing energy consumption (i.e. emissions reduction, cost, effectiveness of technologies)
- Identify Markham's largest energy users and organizations who use a significant amount of energy on a monthly basis to pilot demonstration projects
- Create an engagement strategy to engage small businesses in Markham where individual energy use is small, but together create significant energy usage within the city

New Construction

- Need to drive the building specification (architect/engineers)
- Educate end users and design professionals (architects/engineers) on initiatives that will deliver the most amount of emissions reductions
- Ensure that the construction process does not substitute "value engineer" out the improved performance
- Need to highlight the post installation feedback loop that emission reduction techniques actually delivered intended reductions
- Lobby the Ontario building energy code to aggressively reduce the energy footprint of new construction
- City of Markham could provide approval prioritization incentives for projects with largest energy emission reductions

Existing Buildings

- Encourage property owners and managers to develop corporate sustainability goals to reduce energy consumption with short-long term goals
- For large leased commercial space, encourage property owners and tenants to break the barriers on implementing energy emission retrofits that have a longer payback period than lease terms

SUSTAINABLE ALTERNATIVES CONSULTING
407-121 Ling Road, Toronto, ON M1E 4Y2
sonja@sustainable-alternatives.ca T: 416-324-9388 www.sustainable-alternatives.ca

Using Local Improvement Charges in Implementation of the City of Markham Energy Descent Plan

by: Sonja Persram, Sustainable Alternatives Consulting Inc.
for: Sustainability Solutions Group in a Collaboration for the City of Markham

August 29, 2017

Executive Summary

The City of Markham has a long-term 'Greenprint'[1] commitment toward carbon neutrality as part of a suite of objectives aimed to achieve a sustainable, socially equitable and prosperous community over a 50- to 100-year timeframe.

Existing building retrofits have been identified in the Greenprint as providing the greatest opportunity for energy efficiency and conservation: key ingredients in achieving a carbon neutral community since residential and commercial sector carbon emissions total 61%.

Markham's Greenprint also includes the use of new financing approaches to help achieve this goal. The Sustainability Solutions Group's Energy Descent Plan for the city incorporates use of Local Improvement Charges (LICs), a financing mechanism authorized by O.Reg. 322/12 under the Municipal Act, 2001 for building energy and water efficiency retrofits. This report explores key aspects of LICs and legal opinion elements that have already been obtained on this regulation's applicability for sectors and uses to be considered in an LIC program, and it analyzes the data for Markham's Energy Descent Plan in a strategy to use LICs for a proportion of the retrofits from 2019 through to 2051.

Additionally, assuming that a future legal opinion identifies LICs are also applicable for the cost increment of new construction of high performance houses and buildings over code, a proportion of these costs are also included in an LIC funding strategy of the Energy Descent Plan.

An analysis of the Markham Energy Descent Plan data indicates that an LIC financing program can be delivered at no net cost to the municipality; and that savings from the higher performance retrofits/construction can exceed payments on an annual basis for a cost-neutral benefit to owners from the first year.

[1] Markham's Greenprint Sustainability Plan, 2011

1. Introduction

The City of Markham's 'Greenprint' commitment toward long-term carbon neutrality is one of a suite of objectives aimed to achieve a sustainable, socially equitable and prosperous community over a 50- to 100-year timeframe.

Existing building retrofits have been identified in the Greenprint as providing the greatest opportunity for energy efficiency and conservation: key ingredients in achieving a carbon neutral community since residential and commercial sector carbon emissions total 61%.

Markham's Greenprint also includes the use of new financing approaches to help achieve this goal. The Sustainability Solutions Group's Energy Descent Plan for the city incorporates use of Local Improvement Charges (LICs), a financing mechanism authorized by O.Reg. 322/12 under the Municipal Act, 2001 for building energy and water efficiency retrofits. This report explores key aspects of LICs and legal opinion elements that have already been obtained on this regulation's applicability for sectors and uses to be considered in an LIC program, and it analyzes the data for Markham's Energy Descent Plan in a strategy to use LICs for a proportion of the retrofits from 2019 through to 2051.

Additionally, assuming that a future legal opinion identifies LICs are also applicable for the cost increment of high performance houses and buildings over code, a proportion of these costs are also included in an LIC funding strategy of the Energy Descent Plan.

2. What are Local Improvement Charges

Local Improvement Charges (LICs) are a municipal financing mechanism that allows a municipality to enable up-front financing of private environmental retrofits. Key benefits of this mechanism include the following:

- The LIC enables a stewardship approach to the property by the owner who undertakes the retrofits, as the LIC financing is provided up front to the owner with payments made by that owner and any successive owners until the LIC is paid off.
- Since the LIC is provided over longer terms than banks can provide and is at a fixed rate, this enables affordable deep retrofits over 10, 15 or 20 years, where savings can be intended to exceed payments on an annual basis.
- Because the financing is associated with the property and not the owner, if the owner moves before the LIC is repaid, the next owner continues making the payments and benefiting from the improvements.
- The LIC can be repaid on the property tax bill and provides security to the municipality since any defaulted payments can be treated like taxes and subject to a priority lien that is paid out before mortgages on the property. This security is reflected by a lower investment rate.
- Additional features and benefits are discussed in Section 2.3 on the legal opinion.

3. LIC uses

a. Original LICs

Prior uses of LICs were for financing infrastructure on *public* property, such as buried utilities, sidewalks and parks. The municipality would front the costs and benefiting owners would repay them or a predetermined proportion. The method of assigning costs to a property is different for this type of LIC than for the new regulation.

b. New LIC Regulation

With the approval of Ontario Regulation 322/12, energy and water efficiency are specified measures on private property that can be financed via LICs from the municipality. The regulation also authorizes program costs for marketing, interest and administration to be included in the LIC, which is a critical factor enabling the LIC program's net zero cost to the municipality.

c. Legal Opinion

i. Sectors: The request for the LIC regulation[2] was based on the author's underlying rationale and evidence-based analysis of best practices for the single family residence sector[3] based on discussions with key informants primarily in the US, and key Property Assessed Clean Energy (PACE) proponents of leading US projects.

Subsequent research on using LICs for the commercial building sector is summarized in the author's *Final Report: Local Improvement Charges for Commercial and Industrial Buildings Project*[4] from which the following excerpt is obtained:

> *Rationales for this regulatory change had been provided by this report author's work for the David Suzuki Foundation … The rationales had outlined the case primarily for single family dwellings, and there had been no similar foundation provided for commercial and industrial buildings: the regulation does not specify eligible building types, and considerations for each type had to be addressed.*
>
> *For example, the eligibility of buildings for LIC financing was unclear under the following circumstances: leased as well as owner-occupied buildings; industrial buildings on brownfields; for building energy as well as process energy; and whether buildings not subject to property taxes are eligible – since LICs are repayable on the property tax bill.*
>
> *Additionally, there was no prior discussion about using LICs to address district energy systems, nor whether LICs were also applicable to financing climate change adaptation via installing stormwater management low impact development measures.*

[2] Bill Johnston, Peter Love, David McRobert & Sonja Persram, *Request for a Review of Local Improvement Charges and Related Regulations and Legislation* for the Environmental Commissioner of Ontario, January 11, 2012.
[3] Sonja Persram, "*Property Assessed Payments for Energy Retrofits: Recommendations for Regulatory Change and Optimal Program Features"; "Property Assessed Payments for Energy Retrofits and Other Financing Options";* and *"Strategic Recommendations for an Optimal PAPER Program,"* David Suzuki Foundation and Sustainable Alternatives Consulting Inc., 2011.
[4] Sonja Persram, *Final Report: Local Improvement Charges for Commercial and Industrial Buildings Project,* Sustainable Buildings Canada and Sustainable Alternatives Consulting Inc., 2016.

Also, some additional questions remained as prior legal opinion had: declared LICs to be loans whereas the Ontario Ministry of Municipal Affairs and Housing noted LICs are not loans; and had raised concerns about bonusing (preferential treatment for commercial properties) and whether legislation was needed to require subsequent owners to continue making payments.

The project's legal opinion addressed these issues noted above, and the following excerpt from the final report summarized the legal opinion findings.[5]

Figure 1. Summary of Legal Opinions on the Applicability of LICs for Ontario CI Properties

1) LICs used for a municipal purpose (such as environmental benefit) can be applied to all types of buildings and real property, including conservation authority property and school board property -- except buildings owned by municipalities and their local boards. Note that Crown properties cannot be subject to a priority lien.
2) LICs cannot be used for equipment that is moveable property, i.e. chattels.
3) LICs can be used by owners of leased premises and by lessees or sub-lessees under certain conditions.
4) LICs are unlikely to be used for brownfield sites because of the risk they pose.
5) All permanent aspects of stormwater management systems including low impact development, green roofs, rainwater harvesting and backflow preventers, and other measures such as greywater reuse systems may be financed using LICs. [This segment of the opinion deals with municipalities' capacity to address climate change adaptation.]
6) LICs can finance district energy system connections on private property.
7) LICs are not a loan to the owner, but if repayments of LICs are overdue, the overdue payments become a tax lien; the entire amount of the LIC does not become due.
8) LICs run with the land.
9) Owners can be notified by municipalities of LICs via bills for property taxes, water or garbage.

ii. Financing Sources

Given that LIC amounts for CI buildings would be expected to be larger than those for residential single family dwellings, it was important to ascertain whether LIC financing could be provided by sources other than the municipality. Here is the relevant legal opinion on this topic:

10) LICs are financed by municipalities through their own borrowing, borrowing through provincial lending institutions such as Infrastructure Ontario (IO), or through private lending institutions.

[5] Stanley M. Makuch, B.A., M.A., Juris Doctor, LL.M., *Legal Opinion on Local Improvement Charges for Institutional / Commercial / Industrial Sectors and District Energy Projects,* September 2015, published by Sustainable Buildings Canada and Sustainable Alternatives Consulting Inc.

Additionally, to avert concerns about use of municipally-financed LICs impacting available debt earmarked for specific, other municipal programs, the legal opinion found:

11) If municipalities or IO issue financing for municipal LICs, this general obligation bond financing can be adjusted from calculations of municipal debt totals, i.e. does not impact calculations of municipal borrowing capacity.

In considering financing for LICs as a revolving fund, it would be important to replenish the fund as needed. The LICs for CI Buildings project's legal opinion on this topic follows:

12) LIC financing can be securitized.

4. Additional LIC applications for the City of Markham and its LDC, Alectra[6]:

a. Necessary to understand interaction between the City of Markham and the Region of York

Understanding York Region's participation in its lower-tier municipalities' LIC financing discussions (and in the case of municipally-financed LICs, participation in debenture issues), would require analysis among Regional departments from a legal, finance, building services, and energy and environmental perspectives. If LIC financing comes from a third party, the Region may not need to go to Council if Regional Departments preliminarily analyze and establish the process.

b. Measures and pilot expansion

i. Alectra (previously PowerStream)

1. PowerHouse

The former PowerStream has been aiming to utilize on-site PV as a cost-mitigation approach to expanding distribution. Currently the LDC is piloting a Power.House initiative, which they are aiming to expand. However, when the Power.House pilot is expanded, it will require reducing the owner incentive, and this reduction would be assisted by using LICs to finance the additional amount owners would pay.

There are some issues to be resolved between the current pilot and its expansion. These are as follows. In the current pilot, PowerStream is the owner of the solar PV installations which are on private owners' properties; and the City of Markham has ownership in PowerStream with associated financial arrangements. However, LICs for energy measures are related to private property, therefore LIC viability vis-à-vis PV ownership, and the financing arrangements would need to be resolved.

2. New Houses

[6] Information in this section is based on Sonja Persram, President Sustainable Alternatives Consulting's meetings/ discussions with the City of Vaughan, PowerStream, York Region, and other York Region municipalities from July through December 2016; in addition to materials developed by the partnership between Sustainable Alternatives Consulting Inc. with Sustainable Buildings Canada and EnerQuality, and related material.

There needs to be a written legal opinion on the viability of using LICs for enhancing the performance of new houses; a verbal acknowledgement has been obtained from a legal consultant who has provided opinions since 2010 on this topic.[7] This new opinion would also include applicability for new CI buildings.

3. Energy storage

See Section 3.1.2 above.

4. Electric Vehicle Charging stations

See Section 3.1.2 above for EV charging stations on private property. Charging stations on *public* property may also be subject to LICs – but this would be the first type of LIC and not the more recent regulation. The City of Markham may also wish to seek an opinion on this applicability for existing buildings, as the new building code will include a requirement for charging station rough-ins.

5. LIC program design

Pilots and programs would need to be designed to optimize uptake and for delivery at no net cost to the City of Markham.

c. Property types

As noted above, LICs are applicable for retrofits of single family dwellings, and Ontario CI buildings. LICs have been used for MURBs by the City of Toronto, specifically apartment buildings. It has been noted that new condominiums are ineligible for LICs since developers are not permitted by law to transfer ownership with a 'debt' outstanding.[8] This may be a matter for legal opinion: note that LICs are not loans according to the legal opinion item 7.

d. TBD: existing condo buildings

Given the above analysis it may be viable for LICs to be used for environmental retrofits of existing condominiums. This would also require legal opinion, and in its absence the condominium sector is not included in viable LIC applications in this report. Since condominiums are not segmented from rental apartment buildings, and in the absence of data that identify the relative proportion, a ratio of 20% rental buildings to condominiums is assumed, of which a proportion are analyzed with regards to using LICs for financing high performance upgrades and above-code new construction costs.

5. Why are municipalities engaging in using LICs:[9]

a. Control of program

LICs are a way for municipalities to control a program enabling reductions in energy use and GHG emissions at a zero-net-cost to the municipality. Incremental program costs (for administration, marketing, and interest) are added as an additional LIC charge to the property owner on top of the costs for the installed measures which is then offset by the resulting

[7] Stanley M. Makuch, LL.M., J.D.
[8] Subhi Al Sayed, then Director of Projects, TowerLabs, presentation to CaGBC Greater Toronto Chapter Municipal Leaders Forum, November 8, 2016.
[9] See Note 2.

energy and water savings on an annual basis. The program costs are applied directly as part of participation or other fees, or included into the interest rate spread.

i. A government-led program enables financing of measures that meet government goals. Banks or other non-governmental financing entities do not make meeting government goals a condition of the financing – only the ability to repay.

b. **LIC programs can be designed to offer a net low- or no-cost energy retrofit solution to the property owner**: if the program aim is to have resulting energy savings exceed payments.

i. A municipal-led program allows social equity considerations to be included, such as:
   a. Enabling financing for fiscally-responsible homeowners at all income levels, which in turn enables energy retrofits and utility bill savings.
   b. Providing financing at the same rate for all homeowner financial status levels (banks may offer preferential rates for customers with higher assets/income).

c. LICs remove financing barriers to energy efficiency that primarily benefit social equity:

i. Financing is up-front. A City of Toronto quantitative study[10] looked at reasons why owners did not conduct retrofits after having energy assessments; two-thirds of homeowners who did not carry out all post-audit recommended energy upgrades to their homes said the retrofits were too expensive.

ii. Up-front financing becomes another social equity benefit for owners who are fiscally responsible with other uses for their available cash flow or available credit. Over one-half of those not carrying out all post-audit retrofits said they had other uses for their available cash.

iii. There is a longer term for financing than is available through banks, for example 10, 15 and 20-year terms. By contrast, banks' fixed residential financing are typically over 5 years, and for CI buildings financing may be up to 7-10 years.

iv. A fixed rate over these long terms reduces the risk of rising rates for the owner, allows a greater comfort level with the financing affordability, and enables the same, lower rate to be available to all owners, regardless of income level. This is a significant social equity feature since typically owners' access to lower rates at good terms varies directly with their income and assets and with their prior engagement with their financing firm, so the owners who need the best rates and terms are the ones least eligible for them.

v. Programs that aim to have savings from the installed measures exceed payments for the installations on an annual basis due to the longer financing terms available, make energy and water efficiency savings – and GHG emission reductions – affordable. They also address concerns from banking communities since having a net zero or positive cash flow from the retrofits increases the ability to pay.

vi. The new owner continues making any payments still owing on the financing on sale, while continuing to also benefit from the savings. This LIC feature allows owners to invest on behalf of current and future property owners in an investment, stewardship[11] approach.

[10] Ipsos Reid, *City of Toronto Home Energy Retrofit Financing Study,* 2010
[11] The term 'stewardship' applied to LICs is from Bob Baser, P.Eng., in a 2011 Ecology Ottawa briefing paper on LICs.

vii. This financing method leverages utility incentives to achieve enhanced impacts due to the deeper retrofits available.

viii. LICs allow a stewardship approach to their property that enables long-term investments in their energy security to be made for the property by all fiscally responsible owners, regardless of income level.

d. LICs assist the municipality in achieving corporate and community water efficiency goals:

i. The City of Markham can align LIC goals with optimizing for reductions in energy use and GHG emissions via energy efficiency and renewable energy installations, as well as reductions in water use.

ii. Onsite residential/commercial and municipal corporate energy efficiency can be achieved via onsite water efficiency which aggregates at a community level to reduce energy use and water pumping energy costs. Utilizing water efficiency and conservation reduces household water heating costs and utility bills.[12] It also impacts municipal energy costs for water and wastewater treatment and pumping, [13] [14] [15] which account for 38% of Ontario municipal energy use.[16]

e. Reduction of carbon risk

i. Institutions with portfolios of properties – or property financing portfolios that are energy efficient have a lower carbon risk than institutions without energy efficiency in their portfolio and product mix.

f. LICs produce jobs and local economic benefits

i. As of May, 2017, Commercial PACE in the US has funded projects totalling US $400 million,[17] from which an estimated 6,000 jobs were created based on 15 jobs per $1 million spent, including direct, indirect and induced jobs.[18] US Residential PACE funded 154,000 home upgrade projects totalling $US 3,835 million and created 44,500 jobs.

ii. This level of Commercial PACE investments – according to the same study, would have produced 2.5 times that amount, or US $1 billion in gross economic output and 25% of that amount in combined Federal, State and local tax revenues, or about US $100 million. Similarly, for the Residential PACE investments, produced US $9.588

[12] 15 per cent of home energy costs comes from heating water in the hot water tank: York Region, *Water Efficiency: An At-Home Guide,* Water for Tomorrow, http://watercanada.net/2011/savings-at-the-pump/

[13] See also: https://www1.toronto.ca/wps/portal/contentonly?vgnextoid=ce4907ceb6f8e310VgnVCM10000071d60f89RCRD&vgnextchannel=ff3cd4818444f310VgnVCM10000071d60f89RCRD

[14] Maas, Carol, *Greenhouse Gas and Energy Co-Benefits of Water Conservation,* POLIS Research Report 09-01, Water Sustainability Report, POLIS Project on Ecological Governance, 2009. http://polisproject.org/files/pub_database/maas_ghg_.pdf

[15] See also: City of Guelph, *2016 Water Efficiency Strategy Update* http://guelph.ca/wp-content/uploads/WESU_Draft_Final_Report.pdf

[16] Environmental Commissioner of Ontario, *Every Drop Counts: Reducing the Energy and Climate Footprint of Ontario's Water Use: Annual Energy Conservation Report, 2016/2017 (Volume One),* 2017 http://docs.assets.eco.on.ca/reports/energy/2016-2017/Every-Drop-Counts.pdf

[17] See: http://pacenation.us/pace-market-data/

[18] ECONorthwest, *Economic Impact Analysis of Property Assessed Clean Energy (PACE) Programs,* PACENow, 2011; direct jobs are a direct result of the work required; indirect jobs result from other purchases by the companies hired; and induced jobs result from the consumption by those hired in direct and indirect jobs. http://www.pacenation.us/wp-content/uploads/2014/11/Economic-Impact-Analysis-of-Property-Assessed-Clean-Energy-Programs-PACE.pdf

billion in gross economic output and about $US 958 million in combined tax revenues.

g. Municipal leadership

An LIC program positions the municipality as a leader in achieving municipal, provincial and federal carbon targets as well as goals of reducing energy/water use.

6. LICs and potential contributions to the City of Markham Energy Descent Plan

LIC contributions are dependent on: the City of Markham's ramping up of energy efficiency requirements for new and existing buildings, and the plan for EV vehicle uptake, the latter requiring charging stations with energy storage on CI as well as residential properties.

a. Assumptions in this analysis include:
   i. All legal opinions are obtained and pilots and analyses are conducted to ascertain optimal program design as noted in Section 3, and develop stakeholder relationships. Assume this duration is 1-1.5 years, i.e. in year 3 – 2019, LIC scaled-up financing would begin.
   ii. Both energy and water efficiency measures may be applied, particularly in new construction – the latter resulting in lengthening of the life of water infrastructure and reduction of electricity costs for pumping. However, only energy retrofits and cost increments of new construction of net zero and passivhaus standard houses/buildings are analyzed with respect to costs and fuel/energy savings.
   iii. New building code efficiencies and energy escalation factors are included.
   iv. Early adopters for LICs would also be early adopters for higher performance buildings.
   v. Co-Marketing of the programs will be sufficient to stimulate uptake (where the municipality's portion of costs are covered by program expenses passed on to the owners).
   vi. Issues are addressed related to uptake of the Toronto pilot initiative (vis-à-vis comparatively higher uptake by the Halifax and other Nova Scotia pilots). E.g. in the Toronto initiative LICs are considered as loans, whereas the Halifax initiative treated LICs as fees or charges instead.

7. Plan for LICs to Finance High Performance Cost Increments for Above-Code New Houses:

a. New Housing/New Construction

Analyses were conducted assuming that about 25-35% of the capital cost increment of passivhaus/net zero new properties would be financed via LICs. Exceptions were: appliances (since they are moveable), retirement/nursing home (presumed to be under provincial jurisdiction and budget), and buildings presumed to be under municipal jurisdiction (municipal building, fire station, police station, transit terminal, recreation building) or utility ownership.

8. Plan for Retrofits of Existing Homes:

a. Retrofits of existing homes

In the absence of greater granularity, the following assumptions were made in the calculations:

i. The City utilizes a third-party LIC financing approach at the outset so there is no concern about the level of capital costs vis-à-vis the City budget.
ii. For the reasons discussed previously, 25%-35% of apartment properties are included – assuming them to be rental apartment buildings.
iii. Moderate retrofits are carried out per Scenario 1C as noted by Sustainability Solutions Group.

9. Methodology

The LIC analysis was conducted based on the energy descent plan data

The analysis was based on the following assumptions:

a) All properties' retrofits would not exceed 10% of value. This would be logical given home values in the City of Markham.
b) Energy/fuel savings spreadsheet data represent savings from newly retrofitted (or built) properties that particular year. So total energy/fuel savings for any particular year is the sum of savings for that year plus savings for all previous years.
c) For the purposes of the LIC program, retrofits are anticipated to begin in 2019.
d) LICs are estimated based on a rounded amount, although actual numbers would not be rounded.
e) Capital costs for the LICs are equally spread over the stated property types (highlighted rows in the excel files represent properties that would not be using LICs: for non-residential properties – hospitals, fire stations, police stations, transit terminals, airport, municipal building, recreation/community centres, golf course, and utility property. Some comments:
    - Although hospitals would be eligible for LICs, ESCOs would conduct the retrofits using long-term financing.
    - The airport would be subject to a complex budget combination among all governments.
    - Utility property would be retrofitted or constructed via self-financing.
f) The amount spent on each measure type in each property type in the LIC programs is directly related to ratio of the total LICs for that year divided by the total retrofit costs for eligible properties for that year.
g) Energy/fuel savings for each use (e.g. space heating) in each relevant property type are directly related to the ratio of the total LIC to the total capital cost of all retrofits for the relevant segments.
h) No appliances would be invested in with residential LIC financing. This is due to assumptions that the appliances are moveable and that the appliances would be replaced before the end of the financing term. All measures would be required to

have a life span equal to or greater than the financing term to be eligible for the LIC investment.

The data analysis would be different from the actual implementation. One particular example might be consideration of policies around house value via-a-vis the cap on LIC financing. For example, will the City of Markham plan for an LIC investment cap, or a cap based on property value (typically 10% for LICs is a best practice). If the latter, this could potentially provide more financing to higher-income owners. Also, will Markham plan to extend the program to all postal codes, equally, or to some postal codes first (e.g. greener codes to enhance uptake at program outset, and lower-income postal codes as a social equity factor)?

10. Strategies for house/building sectors

Home Energy Retrofits

Approximately 25-35% of retrofits planned each year for applicable sectors are presumed to be financed by LICs: this proportion grows in each sector and is fairly moderate.

Rental Apartment Buildings

A higher proportion of rental apartment buildings are assumed to be financed via LICs. Although there is an absence of data on the relative numbers of rental buildings vis-à-vis condominiums, it is further assumed that obtaining condo owners permissions to engage in retrofits would be more difficult and so that fewer condominiums would be retrofitted. The relative proportion then of the apartment building retrofits and of the high performance new construction are assumed to be in the same range as of the residential sector: approximately 25-35%.

Existing CI Buildings

Estimates for the purposes of this study are for across-the-board retrofits for targeted building segments based on the prior assumptions: that is, 25-35% of retrofits for pertinent sectors would be anticipated to be financed using LICs.

Granular information on retrofits by floor area will allow a refined implementation plan for CI buildings which would incorporate energy services companies' (ESCOs') involvement in the retrofits as follows:

> Information on anticipated uptake of LICs for this sector is based on the information LICs for CI Buildings project segment in which a qualitative market analysis was conducted of stakeholders' anticipated uptake of CI LIC projects with similar features to US program best practices. These findings are also outlined in the LICs for CI Buildings Final Report by this author[19] for the Sustainable Buildings Canada/Sustainable Alternatives Consulting project excerpted below.

[19] Op. cit.: see note 3.

Table 1. Buildings that can benefit from LICs

Stakeholders in the LICs for CI buildings study noted that LICs could benefit the following buildings:

- All building types except for universities with endowments (*as recommended by*: ESCO 3)
- Industrial buildings (ESCO 1, Canadian Manufacturers & Exporters)
- Commercial buildings owned independently (ESCO 3)
- Commercial buildings between 30,000 and 200,000 sf (ESCO 3)
- Commercial buildings 100,000 sf needing $500,000 in retrofits minimum (ESCO 2)
- Commercial buildings 50,000 sf needing $1 million in retrofits minimum (ESCO 4)
- Owners with fewer options for financing energy retrofits (*as recommended by:* Utilities and industry associations)

Note that it is anticipated that there would be a longer sales cycle for CI buildings, based on the LICs for CI Buildings study findings; and that some market sector leaders would nevertheless be early adopters.

a. Future granular analysis could include the following from additional study findings:
    i. Segment all building types except eliminate all universities with endowments.
    ii. Identify where possible:
        1. Commercial buildings owned independently.
        2. Commercial buildings between 30,000 and 200,000 sf needing $500,000 in retrofits
        3. Segment out those buildings owned by large entities like pension funds: they would be less likely to need LICs as these owners have more options to self-finance energy retrofits.
    iii. Identify building energy cost upgrades for industrial buildings (not process energy since a portion of process energy costs may be applicable i.e. where they are not moveable).
    iv. Create estimates of LIC uptake based on 20%, 50%, 75% uptake.
    v. Note # buildings also.
    vi. Start estimates of LIC uptake after 1-2 years (longer sales cycle for these building types).

New CI Buildings:

Identify goals for buildings performing above-code that meet the above sectoral, ownership and size criteria: schools, post-secondary educational institutions, hotels/motels, retail, buildings associated with vehicle and heavy equipment service, restaurants, museums and art galleries (assumed to be private), retail residential (assuming this is different from commercial residential i.e. not rental apartment buildings), commercial retail, commercial, religious institutions and warehouses (assuming that none of the sectors include brownfield).

Identify cost increments for building above code for the eligible buildings.

11. Findings

Table 10.1 summarizes LIC investments and impacts of those investments as follows:

- **capital costs, fuel cost savings** and **energy cost savings associated with LIC capital cost investments**
- for both **retrofits** and **new construction incremental costs over code of: net zero and passivhaus high performance homes / passive standard high performance buildings**
- for applicable building segments in both **residential** and **non-residential sectors**
- showing both Totals and investments/impacts in 2019 – the first year.

Table 10.1 LIC investments and impacts of those investments

Residential Retrofits Investments/Impacts	**Totals 2019-2051 (constant dollars)**	**Residential Retrofits Investments/Impacts in 2019 (constant dollars)**
Capital Costs	$380,000,000	2,000,000
LIC Impacts: Fuel Cost Savings	$69,191,880	$193,985
LIC Impacts: Energy Cost Savings	$4,208,333	$17,412
Non-Residential Retrofits Investments/Impacts	**Totals 2019-2051 (constant dollars)**	**Non-Residential Retrofits Investments/Impacts in 2019 (constant dollars)**
Capital Costs	$58,500,000	$1,500,000
LIC Impacts: Fuel Cost Savings	$27,966,555	$729,943
LIC Impacts: Energy Cost Savings	$2,273,791	$50,839
Residential New Construction Net Zero / Passive House Investments/Impacts	**Totals 2019-2051 (constant dollars)**	**Residential New Construction Net Zero / Passive House Investments/Impacts in 2019 (constant dollars)**
Capital Costs	105,000,000	500,000
LIC Impacts: Fuel Cost Savings	18,664,307	62,455
LIC Impacts: Energy Cost Savings	1,222,665	4,776
Non-Residential New Construction Passive Investments/Impacts	**Totals 2019-2051 (constant dollars)**	**Non-Residential NC Passive Investments/Impacts in 2019 (constant dollars)**
Capital Costs	$28,400,000	$300,000
LIC Impacts: Fuel Cost Savings	$12,487,070	$86,037
LIC Impacts: Energy Cost Savings	$461,959	$7,959

An analysis of the data indicates the following:

- **LIC program could be delivered on a cost-neutral basis for owners:** Using a very rough calculation, it appears that amortizing the first year's (2019's) investments over 15 years with monthly payments at rates of up to 7% show the total fuel and energy savings in the first year would exceed annual payments in every category. Although 7% may be too high to

generate market interest the intent of this particular calculation is to demonstrate that even at that rate the owner would have a net benefit.

- **LIC program could be delivered on a cost-neutral basis for the City of Markham:** There seems to be a very broad interest rate spread that can accommodate program expenses for a cost-neutral program delivery (if that is the sole method of program cost recovery). That is, if rates remain about in the current range, since Infrastructure Ontario financing to municipalities is now less than 3.1% over 15 years,[20] the program would seem to be deliverable on a cost neutral basis.
  For example, if program costs at the outset are at about 12% of the financing (a high but very conservative estimate), and later fall to about 5% of financing in subsequent tranches; and if ongoing program costs are anticipated to be incurred for each tranche over the duration of the financing, one way to consider cost-neutral feasibility is to look at the difference in interest to be paid by an owner on $500,000 between a rate of 3.1% ($82,138) that the municipality would pay and (for example) 5.5% ($151,157) that the owner would pay. This roughly amounts to $69,000 interest to be paid over the term to cover the program costs of 12% of $500K or $60,000 incurred over the term in this early tranche.

- There are other methods to contribute to early recovery of some program expenses outlined in the consultant's previously cited reports for the David Suzuki Foundation.

11. Conclusion

Local Improvement Charges are one tool that the City of Markham can use in achieving net zero community energy efficiency targets over the long term.

LICs are a feasible method to achieve net annual savings on owners' energy and fuel utility bills. An analysis of the Markham Energy Descent Plan data indicates that payments exceed costs on an annual basis resulting in a cost-neutral owner benefit. This approach includes a moderate use of LICs to support the costs of achieving higher performance via retrofits, and via enhancements over code for new construction.

Additionally, further analysis of the Markham Energy Descent Plan data indicates that **LIC programs could be delivered on a basis that is cost neutral to the City of Markham.**

[20] Rates as at 29 Aug, 2017: http://www.infrastructureontario.ca/Lending-Rates/?ekfrm=2147483942&sector=mun

SSG SUSTAINABILITY SOLUTIONS GROUP

whatIf?