Energy Conservation and Demand Management Plan

Due date: July 1, 2019.

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EDUCATION SECTOR BACKGROUND

Funding and Energy Management Planning

All school boards receive 100% of their funding from the Ministry of Education.

The Ministry announces each Board's funding assignment in March for the next school board Fiscal Year (September 1st to August 31st). The Ministry gives funding only on a year-by-year basis.

While a board may have a five-year energy management strategy, the ability to implement their strategy depends on the funding that's received for each of the five years covered by their plan.

Ontario Regulation 507/18

Ontario Regulation 507/18, under the Green Energy Act, requires that School Boards develop and implement successive 5-year Energy Conservation and Demand Management (CDM) plans. The current deadline for the 5-year plan is July 01/2019.

The Regulation requires the typical CDM plant to include information on each Board's energy consumption, future reduction targets for the next 5-year period, proposed energy saving measures and information on renewable energy projects.

It is the intent of TDSB to make the current CDM plan available on the Board's public web site, its internal intranet and in printed format available for any interested party at the 5050 Yonge Administration Centre.

Asset Portfolio and Energy Management Planning

The education sector is unique in that a Board's asset portfolio can experience significant fluctuations that crucially impact a Board's energy consumption over a five-year period. The TDSB's building portfolio is dynamic in the sense that over time, the Board may reduce its holdings through the sale or lease of buildings, but at the same time, more space may be added through the construction of new schools and additions.

For this reason, a quantitative energy reduction target should not be based on the overall consumption of electricity and natural gas, but on the energy intensity of our buildings. Energy intensity is a measure of the combined use of electricity and natural gas on a square-metre basis, expressed in mega joules per square metre (kWh/m^2). Where natural gas is concerned, the energy use is converted from m^3 burnt to kWh based on the specific heat content of the fuel.

Using the energy intensity as a metric to determine the Board's energy usage, the variable square footage of the Board's portfolio is no longer impacting the results.

The following is a list of some of the most common variables and metrics that change in the education sector.

Facility Variables:

- Construction
  - Year built
  - Number of floors
  - Orientation of the building
- Building Area
  - Major additions
  - Sites sold/closed/demolished/leased
  - Portables
    - Installed
    - Removed
  - Areas under construction
- Equipment/Systems
  - Age
  - Type of technology
  - Lifecycle
  - Percentage of air-conditioned space
- Site Use
  - Elementary school
  - Secondary school
  - Administrative building
  - Maintenance/warehouse facility
  - Community Hubs
- Shared Site Use (For example: two or more boards share common areas and/or partnered with a municipality)
  - Swimming pools
  - Libraries
  - Lighted sports fields
  - Sports domes

Other Variables:

- Programs
  - Child care
  - Before/After School Programs
  - Summer School
  - Community Use
    - Outdoor ice rinks
- Occupancy
  - Significant increase or decrease in number of students
  - Significant increase in the hours of operation

    - New programs being added to a site
- Air Conditioning
    - Significant increase in air-conditioned space
    - Portables

PART I: A REVIEW OF PROGRESS & ACHIEVEMENTS in the PAST FIVE YEARS

A. The Board's Asset Portfolio

The following table outlines the energy-related variables and metrics in the Board's asset portfolio that changed from the baseline Fiscal Year 2012 to 2013 to the end of the five-year reporting period Fiscal Year 2017 to 2018.

Table 1: Board's Asset Portfolio

Key Metrics	(Baseline Year) Fiscal Year 2012 to 2013	Fiscal Year 2017 to 2018	Variance
Total Number of Buildings	594	586	-8
Total Number of Portables/Port-o-paks	570	557	-13
Total Floor Area (m^2)	4,098,371	4,100,160	+1,789
Average Operating Hours	80/week	80/week	0
Average Daily Enrolment			
Other Relevant Changes in the Operation of Assets: Emergency cooling centers/libraries A/C	nil	1,695 ton (5,955 kW) cooling added	+5,955 kW

B. Energy Usage Data for the Board

- The following table lists the "metered"[1] consumption values in the common unit of Equivalent Kilowatt Hours (ekWh) and Kilowatt Hours (kWh). Metered (also known as "raw") consumption data is unable to measure the impact of weather on energy usage and as a result it does not allow an accurate analysis of energy performance from one year to the next. The metered information it tabulated below.

Table 2 – Raw Utilities Data (meter-measured)

Baseline Year	Gas (e-kWh)	Hydro (kWh)	Total (e-kWh)	Area (m^2)	Energy Intensity (kWh/m^2)	% change
2013	766,403,851	274,384,939	1,040,788,791	4,098,371	253.95	100.00%
2014	787,823,300	273,487,635	1,061,310,935	4,078,044	260.25	102.48%
2015	765,282,422	273,636,250	1,038,918,672	4,093,648	253.79	99.94%
2016	635,077,051	278,530,081	913,607,132	4,098,254	222.93	87.78%
2017	635,330,981	273,954,479	909,285,460	4,096,801	221.95	87.40%
2018	651,620,889	275,443,996	927,064,885	4,104,891	225.84	88.93%

Notes:

During the last 5 years, TDSB purchased a small amount of district heat/district cooling energy. The district energy purchases amount to less than 0.25% of the total Board energy usage and are too small to take into account. For the foreseeable future, TDSB does not intend to increase its share of purchased district heating/cooling needs.

C. Weather Normalized Energy Consumption Values

In Ontario, 25% to 35% of energy consumption for a facility is affected by weather. The best way to compare energy usage values from one year to another is to use weather normalized values as they take into consideration the impact of weather on energy performance and allows an "apple-to-apple" comparison of consumption across multiple years.

In addition to the impact of the weather, the fluctuations in the Board portfolio which changes from year to year. Such fluctuations are reflected not only in the total square footage of the buildings but also in the level of services associated with each building; for example air conditioning is added to numerous schools, operating schedule vary, etc. All these factors impact the total energy usage of the Board.

As a result, the yearly energy usage needs to be normalized to a "standard" weather system of reference and then normalized again with respect to the Board portfolio each year.

1 Metered consumption is the quantity of energy used and does not include a loss adjustment value (the quantity of energy lost in transmission).

To demonstrate the effect of weather, the following table shows the Weighted Average Heating Degree Days (HDD)[2] and Cooling Degree Days (CDD)[3] for the six most common Environment Canada weather stations in the Ontario education sector.

The balance point for calculating the above HDD and CDD values is 18 degrees Celsius. This is the most common used value and signifies the outdoor temperature at which heating is no longer necessary and mechanical cooling (wherever available) is energized.

Table 3: Ontario Degree-days

Ontario Degree Days	Fiscal Year 2012 to 2013	Fiscal Year 2013 to 2014	Fiscal Year 2014 to 2015	Fiscal Year 2015 to 2016	Fiscal Year 2016 to 2017	Fiscal Year 2017 to 2018
HDD	3797	4106	3769	3464	3518	3765
CDD	337	262	349	564	345	516

Sources:

https://toronto.weatherstats.ca/metrics/hdd.html

https://toronto.weatherstats.ca/metrics/cdd.html

It must be noted that:

- All schools are heated throughout the entire winter season, therefore the impact of the year-to-year weather fluctuations is significant and has been accounted for.
- A relatively small percentage of the TDSB schools are fully air conditioned; other schools have partial air conditioning (ranging between 25% to 50% of the total area), while other schools have no mechanical cooling at all. Additionally, most schools are not operational during the peak cooling season (July/August) and all air conditioning systems are off during unoccupied periods. Therefore, the impact of weather fluctuations for cooling purposes is considered negligible and the actual "raw" data is used.

The table below shows the energy usage and energy intensity normalized for weather fluctuations and variances in Board portfolio square footage.

Table 4 – Weather Normalized Utilities Data

Baseline Year	Gas (e-kWh)	Hydro (kWh)	Total (e-kWh)	Area (m^2)	Energy Intensity (kWh/m^2)	% change
2013	739,270,173	274,384,939	1,013,655,113	4,098,371	247.33	100%
2014	702,742,111	273,487,635	976,229,746	4,078,044	239.39	96.79%
2015	743,672,468	273,636,250	1,017,308,718	4,093,648	248.51	100.48%
2016	671,482,408	278,530,081	950,012,489	4,098,254	231.81	93.72%
2017	661,439,767	273,954,479	935,394,246	4,096,801	228.32	92.31%
2018	633,893,240	275,443,996	909,337,236	4,104,891	221.53	89.57%

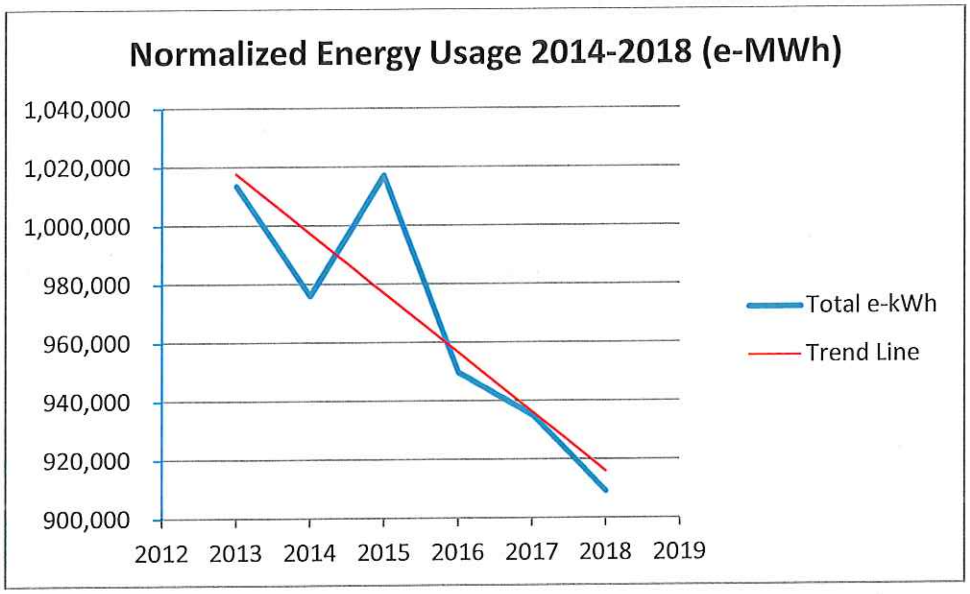
[2] Heating Degree Day (HDD) is a measure used to quantify the impact of cold weather on energy use. In the data above, HDD are the number of degrees that a day's average temperature is below 18C (the balance point), the temperature at which most buildings need to be heated.
[3] Cooling Degree Day (CDD) is a measure used to quantify the impact of hot weather on energy use. In the data above, CDD are the number of degrees that a day's average temperature is above 18C, the temperature at which most buildings need to be cooled. It should be noted that not all buildings have air conditioning and some building have partial air conditioning. The UCD only applies CDD to meters that demonstrate an increase in consumption due to air conditioning.

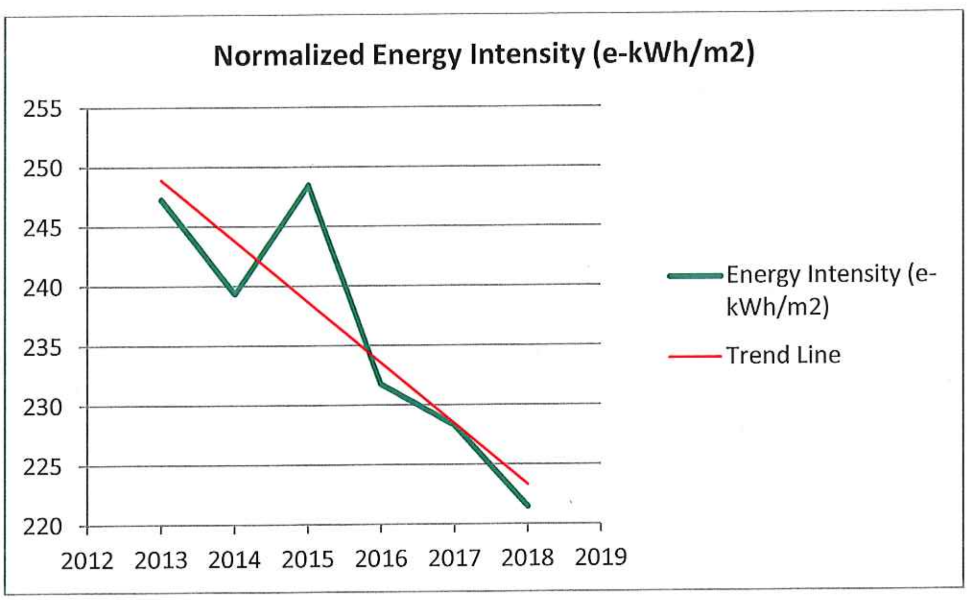
The data in the weather normalized table can be summarized as follows:

Between 2014 and 2018, the Board saved the equivalent of 279,993,127 e-kWh referenced to the 2013 baseline.

The Energy intensity varied from year to year, with values ranging from a loss of 0.48% in 2015 to a maximum saving of 10.43% in 2018. Averaging the energy intensities over the 2014-2018 period, the decrease is 5.43% (233.91 e-kWh/m^2) and is well aligned with the 5% target set against the 2013 baseline.

Graphically, the year-to-year normalized energy usage and energy intensity are shown below:





A closer look at the data included in the table reveals that the savings are almost exclusively related to gas usage. This correlates well with the actual renewal work completed by the Board during the period considered.

The Board spent over $78 million in heating plant upgrades and since 2016 and is engaged in a sustained effort to replace all the existing steam plants. Simultaneously, over $166 million were spent replacing roofs and adding insulation, complemented by a $43 million expenditure in windows replacement, the result being a substantial decrease in heating costs.

As for the hydro usage, the energy intensity varied vary little; this is caused by minimal investment in lighting conversions to LED and addition of mechanical air conditioning as part of the emergency cooling program. The Board added approx 5,955 kW of mechanical cooling, offsetting any savings resulting from replacing old chillers and cooling towers with more efficient ones.

D. Additional Notes

The Conservation Goals were forecasted in the spring of 2014. Since then several factors, which impact energy use, have been introduced to the education sector that may either raise or limit a board's ability to make the forecasted Conservation Goals.

Some of these factors include:

Full Day Kindergarten (also known as FDK)

The introduction of FDK created many new spaces through new additions or major renovations of existing facilities. The result was more floor area and sometimes more energy-intensive designs due to factors such as:

- Higher ventilation requirements,
- Use of air conditioning, etc.

These factors increase the energy intensity of a building. Under FDK, spaces for more than 470,000 new students were added to the education sector.

Before and After School Programs

These programs were implemented to help the introduction of FDK spaces. However, Before-School and After-School Programs need a facility's Heating, Conditioning, and Air Conditioning (also known as HVAC) system to operate for an extended period of time on a daily basis, which will increase the overall energy intensity.

Community Use of Schools

The Ministry of Education introduced funding to all school boards, so they can make school space more affordable for use after hours. Both indoor and outdoor school space is available to not-for-profit community groups at reduced rates, outside of regular school hours. The use of spaces in schools, typically gymnasiums and libraries, increased to maximum usage. The use of these spaces during non-school hours requires a facility's HVAC system to operate for an extended period of time on a daily basis, which will increase the overall energy intensity.

Community Hubs

In 2016, the Ministry of Education introduced funding for boards to carry out Community Hubs within their asset portfolios. As a result, many schools now offer a greater range of:

- events (cultural),
- programs (arts, recreation, childcare), and
- services (health, family resource centres).

The dramatic increase in community use means that many schools now run from 6:00 a.m. until 11:00 p.m. during weekdays and are open many times on weekends. The use of these spaces during non-school hours requires a facility's HVAC system to operate for an extended period of time on a daily basis, which will increase the overall energy intensity.

Air Conditioning

Historically, schools have not had air conditioning, or it has been a minimal space in the facility. However, with changing weather patterns, "shoulder seasons" such as May, June and September are experiencing higher than normal temperatures. Parents are demanding that schools have air conditioning. Air conditioning significantly increases a facility's energy use.

Compliance with current Ontario Building Code (also known as OBC)

When renovations or an addition is built onto an existing school, in-place equipment such as HVAC systems, lighting etc., may be required to meet up-to-date OBC standards which may result in increased energy use.

For example under the OBC, buildings built today have increased ventilation requirements, meaning more outside air is brought into a facility. As a result, HVAC systems need to work longer to heat or cool the outdoor air to bring it to the same temperature as the standard indoor temperature for the building.

E. Review of Previous Energy Conservation Goals and Achievements

In 2014, the Board set an annual energy conservation goal at 1% annually for the next 5 years, for an aggregate value of 5% over the noted period. The following table compares the Energy Intensity Conservation Goal with the Actual Energy Intensity for each year (all normalized to weather data and size of Board portfolio).

Table 5: Comparison of Energy Intensity Conservation Goal and Actual Energy Intensity Reduced

	2014	2015	2016	2017	2018	Total With No Reduction	Predicted % Savings	Predicted Reduction
Baseline Intensity (kWh/m^2)	247.33	247.33	247.33	247.33	247.33	1,236.65	**5%**	**61.83**
	2014	**2015**	**2016**	**2017**	**2018**	**Actual Total**	**Actual % Savings**	**Actual Reduction**
Actual Intensity (kWh/m^2)	239.39	248.51	231.81	228.32	221.53	1,169.56	**5.43%**	**67.09**

The data in the table above indicates that the predicted 5% energy intensity reduction over the 2014-2018 period was envisioned at 61.83 kWh/m^2.

The actual normalized energy intensity has seen a cumulated improvement of 67.09 kWh/m^2, slightly exceeding the predicted target.

F. Measures Implemented from Fiscal Year 2012 to 2013 to Fiscal Year 2017 to 2018

A list of the measures implemented, the related costs, and the fiscal year that the measure was implemented within the Board are outlined in below.

a. Executive Summary

The total identified backlog of overdue work required to be undertaken by the Board in order to keep the buildings in good operating conditions has been evaluated at over $4 billion.

During the 2014-2018 period, the Board allocated over $271 million to renew and replace deteriorated building services and building envelope elements affecting a portfolio of more than 42 million sq.ft. The backlog reduction and various emergencies were the main rationale when establishing the budgetary targets and projects to be executed each year. During the period considered, there was no specific budget allocated solely to improving energy efficiency, where payback was the determining factor in the selection of projects.

With this said, all renewal work had a positive impact on the efficiency of the systems affected; new efficient equipment was installed, improved controls helped eliminate waste and improvements in the quality of the building envelope decreased the heating and cooling loads of the buildings.

The table below identifies the impact of major renewal work completed between 2014-2018 on the energy usage of the Board. A cursory comparison between the expenditures and cost savings associated with the energy reduction confirms that need rather than payback was the determining factor (energy savings normalized to weather HDD_{18}).

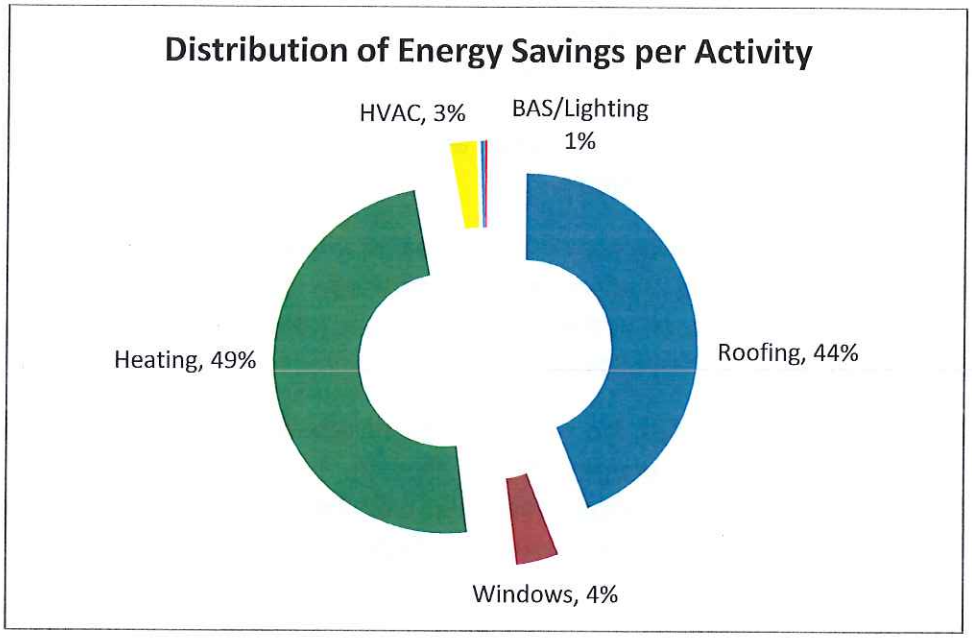
Table 6: Energy Savings Derived From Renewal Work

Year	Total Energy Savings (ekWh)	Total CO_2 reduction (ton)	Utilities Cost Reduction ($)	Budget Investment ($)	% of Total TDSB Energy	% of Total TDSB Costs	% of Total CO_2 Emissions (ton CO_2)
2014	7,217,717	11,668	$226,899	$35,959,795	0.68%	0.37%	0.88%
2015	11,869,826	17,51	$357,085	$48,578,098	1.12%	0.59%	1.33%
2016	13,072,540	17,435	$403,347	$40,506,647	1.42%	0.66%	1.32%
2017	37,142,521	52,141	$944,912	$85,041,993	4.05%	1.55%	3.95%
2018	29,384,932	43,285	$886,964	$61,075,815	3.07%	1.45%	3.28%
TOTALS:	**98,687,537**	**142,049**	**$2,819,207**	**$271,162,348**	**1.99%**	**0.97%**	**2.45%**

The results tabulated above indicate that renewal work saved over 98,500 MWh during the 2014-2018 time period.

The analysis of the total energy usage of the Board, normalized to weather fluctuations and variable square footage of the Board indicates that the total energy savings are 279,993 MWh or 5.43% of the total. The majority of the savings are related to the renewal of heating and DHW equipment. There have been substantial improvements in the electrically-operated equipment (pumps, fans) and some progress on lighting retrofits; however, savings achieved in electrical consumption were offset by the upsurge of air conditioning installations.

The following graph represents the distribution of energy savings among different type of renewal/upgrade projects undertaken during 2014-2019:



The energy savings associated with major renewal projects represent 35.26% of the total; the rest is attributable to the continuous maintenance and repair work (such as leaking valves replacement, pneumatic tubing replacement, air balancing, greasing of damper bearings, tightening of fan belts, replacement of gaskets, etc) and changes in behavioural approach to energy conservation (such as making sure lights are off when not needed, windows are closed when not needed to be open, etc). Such measure are too small to be included in the major renewal programs but their effect accrues and in the end yields substantial results.

b. Roofing Replacement

Roofing replacement work was performed to meet two objectives:

- Urgent repairs required to terminate leaks and further deterioration of the roofing layer.

- Replacement of old roof sections deemed as critical due to their age and general deterioration

In most instances, the old roofing materials were originally applied directly onto the supporting deck, with little or no insulation. The renewal work involved the removal of the old roofing materials, local repairs to the deck, applying a new layer of R-20 insulation, re-building the drainage slope and the installation of a new water-proofing membrane complemented by a top layer of asphalt or gravel. New drains were installed and existing rain water leaders were cleaned or replaced (partially or totally).

The addition of insulation reduced significantly the heat losses and heat gains during the winter and respectively the summer. As noted previously, given the limited amount of mechanical cooling available throughout the TDSB portfolio and the limited usage time, the energy savings during the cooling season were considered negligible; this report includes only savings related to the energy savings during the heating period.

During the 2014-2018 period, the Board replaced more than 13 million sq.ft. of roofing at a cumulated cost of more than $166.5 million. The total estimated energy savings during the noted period amount to over 43,400 MWh; the equivalent cost savings, at an average price of $\$0.271/m^3$ is $1,104,953. While significant, the cumulated savings confirm that the main driver behind the roofing renewal work was age/deterioration and not financial payback considerations.

The table below breaks down the amount of roofing work performed, the associated costs and calculated savings related to the addition of insulation.

Table 7: Energy Savings Derived From Roofing Renewal

Year	Roof Replacement Area (sq.ft.)	Replacement costs ($)	Estimated energy savings (ekWh)	CO_2 avoidance (ton)
2014	2,132,871.00	$29,056,604.63	6,907,748.06	10,154.39
2015	3,482,171.00	$43,993,486.59	11,277,737.84	16,578.27
2016	2,761,098.00	$30,853,588.54	8,942,392.37	13,145.32
2017	2,592,674.00	$30,216,932.72	8,396,916.08	12,343.47
2018	2,438,822.00	$32,438,646.70	7,898,634.26	11,610.99
TOTALS:	**13,407,636**	**$166,559,259.18**	**43,423,428.61**	**63,832.44**

c. Windows Replacement

Windows replacement work is performed to address the deterioration of old windows, mostly of single glazed type with wood frames. Over time, the window frames cracked, the seals shrunk and the infiltration rates became unacceptable. At the same time, the single glazed window panes offer almost no thermal resistance; during cold periods, it is not uncommon to notice ample amounts of condensation on these windows, leading to further wear and tear of the frames.

The typical new windows used are sealed double glazed units, with thermally broken aluminum frames, U-value of 3.679 W/m^2. The new windows cut in a significant way both the envelope transmission losses and the heat required to temper the infiltration. For the reasons noted above, the impact of windows replacement on cooling loads has not been accounted for; the old windows being replaced are usually found in schools built in the 1950's or early 1960's, in which mechanical cooling is sparse.

For infiltration rates, the methodology included in the ASHRAE Fundamentals Handbook was used, with an average wind speed of 15 km/hr.

Only project of a certain magnitude were considered (at least half a building elevations or more); the occasional replacement of a small number of windows has a very small impact. During the 2014-2018 timeframe, a total of over 132,900 sq.ft. of windows were replaced at a total cost of over $15.2 million. The cumulated estimated savings are over 3,900 MWh which translate into a total cost avoidance of $99,400 (rounded). As noted previously, comparing the cost benefits relative to the total expenditures, the financial benefits derived from the work are minimal; the work was done primarily to reduce the backlog of obsolete building elements and to improve the learning environment of students.

The table below breaks down the amount of windows replacement work performed, the associated costs and calculated savings related to the addition of insulation.

Table 8: Energy Savings Derived From Windows Replacements

Year	Windows Replacement Area (sq.ft.)	Replacement costs ($)	Estimated envelope energy savings (ekWh)	Infiltration Load (kWh)	Total Energy Savings (ekWh)	CO2 avoidance (ton)
2014	35,871	$4,125,171	479,743	203,103	682,847	1,003
2015	3,835	$441,025	51,289	224,817	276,107	405
2016	6,667	$766,705	89,165	262,566	351,732	517
2017	74,533	$8,571,260	996,807	684,575	1,681,383	2,471
2018	11,998	$1,379,770	160,462	752,508	912,971	1,342
TOTALS:	**132,904**	**$15,283,931**	**1,777,466**	**2,127,569**	**3,905,040**	**5,738**

d. Building Automation

During the time period considered, the majority of the BAS upgrades were combined with other building services improvements, such as air handling, chillers and boiler replacements (see section below).

The independent BAS upgrades completed during 2014-2018 consisted mostly of programming, connectivity and control panels replacements which allowed the migration of software and graphics onto the main TDSB server. This allowed the TDSB technicians to access the upgraded sites through the web rather than the slow dial-in protocol used previously, when each school had a dedicated BAS workstation.

The achieved savings were estimated by taking into account improvements in trouble-shooting, early monitoring and detecting of systems operating outside the prescribed parameters. The TDSB technical personnel can access any site connected to the main server, or multiple sites simultaneously, and make changes, correct parameters found to be out of bounds or perform other functions (over-rides, etc.).

The table below breaks down the independent BAS upgrade projects performed, and the estimated savings resulting from better scheduling, de-bugging routines and other similar activities.

Table 9: Energy Savings Derived From Independent BAS Upgrades

Number of Projects	Area Affected (sq.ft.)	Upgrade Costs ($)	Estimated Gas Savings (ekWh)	Estimated Hydro Saving (ekWh)	Total Energy savings (ekWh)	CO_2 Avoidance (ton)
none	-	-	-	-	-	-
1	150,425	$272,950	66,379.99	9,680.83	76,060.82	101.37
1	56,871	$665,000	53,801.50	28,831.82	82,633.32	90.39
1	34,275	$94,162	15,234.76	4,281.32	19,516.08	24.07
3	242,315	$1,073,366	118,197.84	44,245.03	162,442.87	191.09
TOTALS:	**483,886**	**$2,105,478**	**253,614.09**	**87,039**	**340,653.09**	**406.92**

e. Heating Plant Renewals

The TDSB is unique relative to other Ontario school boards, when considering the number and age of heating plants. The Board operates close to 600 heating plants containing over 1,300 boilers of almost every type ever built; as of 2014, the Board operated over 130 steam plants, some being of the high pressure type (80-110 psi) and requiring permanent supervision.

The majority of the schools were built in the post WW2 boom period and the average age of the TDSB heating plants is 40 years, exceeding by far the median life expectancy of the equipment.

It is then not surprising that TDSB is engaged in a sustained effort to renew its heating equipment stock, modernizing it, improving its efficiency and equipping it with modern controls. In addition to replacing obsolete hot water plants, the TDSB has adopted a long term strategy to replace all the steam plants with new hot water based ones. Steam plants are particularly inefficient, given the inherent losses associated with purging, venting, steam flashing and other losses generated by poor controllability, defective steam traps and un-insulated condensate return piping.

The TDSB adopted a heating plant model which includes a pair of sectional cast iron boilers equipped with modulating linkage-less burners. The noted equipment has been selected for its superior robustness, ability to be site assembled, together with ease of maintenance and control.

The hot water distribution piping includes primary and secondary loops, interfacing via 3-way mixing valves which allow for precise water temperature scheduling based on outdoor weather and occupied/unoccupied periods. This arrangement allows the use of variable frequency drives (VFDs) on the pumps serving the secondary loops, to match the flows to the variable heating demands of the buildings. At the same time, the use of primary loops allows for a constant flow of water through the boilers.

The building automation system (BAS) in each plant monitors and adjusts the rates of burners firing sequences the duplex equipment to equalize run-time, and monitors the temperature differentials in each loop, ensuring that it is maintained at optimum values. The automation system is capable of totalizing energy usage and trending a variety of parameters (temperatures, pressures, valves positions) to allow for fine tuning of every building.

All piping is insulated throughout, the chemical treatment is monitored frequently and all expansion tanks are pressurized.

Where low temperature water applications are used, the TDSB approach is to use stainless steel condensing boilers, which can reach efficiencies up to 95%. Such applications include pool water heating, radiant floor heating, heat pump loops. In most instances, where condensing boilers are used, primary/secondary loop arrangements are redundant, and the only limitation becomes the minimum floe required for the operation of the boilers.

A particular application are the domestic hot water (DHW) heaters, where all new equipment is exclusively of the condensing type, built of stainless steel and with sealed combustion. The DHW heaters are independent and decoupled from the main heating plant equipment. The typical TDSB approach is to use multiple DHW heaters of up to 120 gallon capacity, enhancing the modulation capacity and providing the necessary redundancy; multiple tanks also allow for scaling up and down the DHW recovery rate without compromising efficiency (such as minor usage during the summer vs full use during the school year).

During the 2014-2018 time period, TDSB invested almost $79 million in renewing 75 heating plants, 20 of which were steam to hot water conversions. This work allowed the Board to save over 4.5 million m^3 gas during the noted timeline, representing over $1.2

million in cumulated utility savings. The savings were estimated by comparing gas meter readings before and after the renewal work; the data is raw type, not normalized to weather.

It must be noted that TDSB has completed an additional 14 heating plant renewals in the summer/fall of 2018, totalling an investment of $7.4 million; the work is not included in this report, since a complete post-construction gas billing data set is not available; this work shall be included in the next CDM report.

The table below breaks down the costs and the estimated savings resulting from heating plant renewals. The upsurge of energy savings is clearly visible after 2016, when the steam to hot water conversion strategic plan was adopted and its implementation commenced.

Table 10: Energy Savings Derived From Heating Plant Renewal

Year	Number of projects	Schools Areas (sq.ft.)	Upgrade Costs ($)	Estimated Gas Savings (ekWh)	CO_2 Avoidance (ton)
2014	4	292,178	$2,401,926	299,473	440.23
2015	6	718,410	$2,802,155	192,542	283.04
2016	9	1,414,716	$7,135,827	2,315,216	3,403.37
2017	31	2,618,195	$43,897,558	25,297,866	37,187.86
2018	25	2,497,095	$22,533,935	20,249,782	29767.18
TOTALS:	**75**	**7,540,594**	**$78,771,401**	**48,354,879**	**71,081.68**

f. Cooling Plants and Central Ventilation Equipment Renewals

Starting in the late 1970`s to optics regarding indoor comfort have changed, and larger schools started to be designed with central cooling plants. Smaller ones (less than 100 ton capacity) are air cooled, while larger one are water-cooled, using cooling towers for heat rejection. Typical original arrangements included reciprocating or scroll compressors on the smaller chillers, or centrifugal compressors on the larger units, equipped with variable inlet vanes.

Most chillers installed in that period have now exceeded their life expectancy are scheduled for renewal. The current TDSB approach to new chiller plants include: magnetic bearing chillers, variable frequency drive for all cooling towers, variable chilled water pumping, all features electronically controlled. The new chiller can operate with a larger range of water flows and their efficiency went up from the original 0.8-0.9 kW/ton to as low as 0.4-0.45 kW/ton. The improved chiller efficiency has an impact not only on the energy use but also on the demand use, especially when using multiple smaller compressors.

When smaller cooling loads are involved, chillers are less economical than DX condensing units associated with air handling equipment. They were the best answer to providing air conditioning to a small group of rooms or to a single zone like a cafeteria or a general purpose room. As these units reach and exceed their life expectancy, they start failing and are being replaced with new ones. The new models come equipped with micro-channel condenser coil technology and VFDs on the condenser fans, capable of matching the heat rejection to the true loads of the building; on the air side, multiple refrigerant circuits are being used with inter-twined circuitry inside the coils, helping with the uniform distribution of temperatures across the face of the coil.

Where air handling systems are involved (with or without cooling), the past approach up to the late 1970's was to keep the equipment indoors in dedicated rooms. While lack of space and access was and remains a problem, keeping the units indoors extended their life expectancy considerably. However, with the bulk of them being installed 50-60 years ago, they start failing and need to be replaced.

When replacing air handling systems, the new TDSB strategy employs numerous new technologies, such as arrays of ECM fan motors, converting multi-zone units to VAV units, demand controlled ventilation using CO_2 sensors, free cooling based on enthalpy rather than temperature sensing, heat recovery and enhanced BAS controls and sequences.

The table below breaks down the costs and the estimated savings resulting from cooling and air distribution systems renewal.

Table 11: Energy Savings Derived From Cooling and HVAC Renewal

Year	Number of projects	Schools Areas (sq.ft.)	Upgrade Costs ($)	Estimated Hydro Savings (kWh)	CO_2 Avoidance (ton)
2014	1	176,540	$376,092	179,739	70.46
2015	1	252,073	$1,068,482	380,945	149.33
2016	2	198,803	$1,085,526	711,985	279.10
2017	7	239,307	$2,239,811	259,140	101.58
2018	8	848,962	$3,627,898	925,109	362.64
TOTALS:	**19**	**1,715,685**	**$8,397,809**	**2,456,918**	**963.11**

g. Lighting Upgrades

The lighting upgrades include measures such as installation of motion sensors and conversion from fluorescent to LED.

The LEED lighting equipment holds the largest promise, both in terms of reduced energy use and projected reliability. The technology is emerging and there are still numerous growing pains in the industry, from equipment of inconsistent quality, wide diversity of pricing and issues related to the supply chain and service.

Starting in 2014, TDSB has experimented with LED technology, using pilot project for different methods of using the new fixtures. Such methods include keeping the fixtures and just replacing the tubes, keeping the ballasts or using separate drivers, using tubes with built-in drivers, or completely replacing the fixtures with new ones, with no tubes but strips of LED lights. Additional technologies include built in motion sensors, automatic multi-step dimming, etc. Meetings and discussions were held with different manufacturers and the performance of the new pilot projects was monitored. Eventually, a consensus has emerged among the TDSB electrical engineering department, to the point where in 2017 TDSB issued a set of design guidelines, for new installations and retrofits (and further separating indoor ceiling lights, high-bay lights in gyms and similar and exterior lights).

An ambitions lighting retrofit program was set in motion at the end of 2017 under the auspices of the GGRF program; unfortunately, the program was cancelled before any projects could be completed.

Considering the above, the lighting upgrade work actually implemented throughout TDSB is small and has not reached its anticipated potential.

The table below summarizes the lighting upgrades activity over the 2014-2018 period.

Table 12: Energy Savings Derived From Lighting Upgrades

Year	Number of Projects	Area Affected (sq.ft.)	Estimated Demand (kW)	Estimated Hydro Savings (kWh)	CO2 avoidance (ton)
2014	-	-	-	-	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	4	382,152	39	137,746	13.05
2018	2	175,915	20	68,873	11.70
TOTALS:	**6**	**558,067**	**59**	**206,619**	**24.75**

h. Renewable Energy Sources

The TDSB entered into an agreement with Potentia Renewable Inc. (PRI) for the installation of photovoltaic solar panels. In broad terms, the agreement had TDSB providing roof space for the installation of the solar panels in exchange for PRI repairing the areas of the roof used. PRI is the beneficiary of the feed-in incentives for a period of 20 years, during which they will maintain and operate the solar systems.

The solar panels were installed in two phases between 2014 and 2018 (FIT-2 and FIT-4 programs). Overall, the program saw the installation of close to 148,000 solar panels with an installed capacity of 37,670 kW. The panels are installed on low-profile metallic racks, tilted at 10^{O} using ballasted securing method, with no roof penetrations. The loss of panels efficiency caused by the low tilt angle is offset by the savings achieved by simplifying the racking support system and having it ballasted rather than solidly anchored to the underlying structure.

The table below summarizes the yearly growth of the solar system and energy produced, as provided by PRI from their records.

Table 13: Energy Produced by Renewable Sources

Year	Number of solar panels	kW installed (kW)	Energy Produced (kWh)	CO_2 Avoidance (ton)
2014	8,844	2,019.20	78,130	30.63
2015	73,644	17,063.68	8,738,415	3,425.46
2016	45,044	12,132.11	30,322,401	11,886.38
2017	-	-	36,312,125	-
2018	19,990	6,454.55	37,616,250	14,745.57
TOTALS:	**147,522**	**37,670**	**113,067,321**	**30,088**

G. Incentives

The TDSB Energy Dept. has maintained close relationships with the utility providers and worked close with their representatives to ensure that every available incentive offered by local, provincial or federal government, or any other organization, is taken into account and applied for.

The nature and size of incentives vary from year to year, initiatives are launched and revised or outright terminated; the process requires that the TDSB continuously monitor the legislation in this field, upgrading its knowledge base and application procedures.

The table below shows the incentives obtained during the 2014-2018 period.

Table 14: Incentives Received for Energy savings

Year	Hydro Incentives ($)	Enbridge Incentives ($)	Total Incentives Received ($)
2014	$103,055	$64,472	$169,541.00
2015	$82,368	$285,217	$369,600.00
2016	-	$149,059	$149,059.00
2017	-	$139,192	$139,192.00
2018	$55,046	$67,703	$124,767.00
TOTALS:	**240,469**	**37,670**	**$952,159.00**

Note: for 2018, some Enbridge incentives are still pending and being evaluated; the tabulated sum represents incentives actually received.

PART II – ENERGY CONSERVATION and DEMAND MANAGEMENT PLAN for FISCAL YEAR 2018 to 2019 to FISCAL YEAR 2023 to 2024

Part II outlines the board's plan to reduce energy consumption through renewable energy and energy management strategies including:

1. Design, Construction and Retrofit
2. Renewable Energy
3. Operations and Maintenance; and lastly
4. Occupant Behavior.
5. Real time energy monitoring to identify abnormalities in usage.

Definitions

Design/Construction/Retrofit

Definition

Design, construction, and retrofit includes the original and ongoing intent of how a building and its systems are to work through the combination of disciplines such as architecture and engineering.

Renewal Energy

Definition

Renewal energy is a strategy to cut down a board's energy use from the province's electricity grid and includes:

- solar panels
- wind turbines, etc.

Operations and Maintenance

Definition

Operations and maintenance include the strategies the Board uses to make sure that the existing buildings and equipment performs at maximum efficiency.

Occupant Behaviour

Definition

Strategies that the Board uses to teach occupants, including staff, students and community users, with an emphasis on changing specific actions to reduce energy consumption.

Plan of Future Actions

1. To date the Board's energy management strategy has been limited by the size of the backlog of renewal work and restriction related to how available funding can be spent.

   As noted in section **F.** of this report, the majority of the energy savings were achieved as a corollary to renewal work; while the Board achieved its reduction target of 5%, very few projects were undertaken with the sole purpose of energy use reduction.

2. For the next 5-year period, renewal work will remain of paramount importance to ensure that the school continue to operate safely and offer an adequate learning environment. We anticipate that intensive work will continue in the areas of heating, cooling and building envelope renewal. Significant energy savings are likely to be achieved, but they will not be the primary objective of such work. To the extent that funding remains at current level, the conversion of steam plants to hot water will continue, providing not only energy savings but also significant operational cost reductions.

3. The use of new technologies will be expanded in areas such as the use of ECM motors, magnetic bearing compressors, pumps with integral built-in VFD drives. New software developments in the BAS field will allow integration of buildings mechanical and electrical services and continuous real-time monitoring of energy usage; deviations from the specified benchmarks will be immediately flagged and the cause will be addressed promptly rather than waiting for months to examine utility bills and realize that something is amiss.

4. With this said, several changes are proposed which will combine renewal and energy management objectives. They include commencing an aggressive retro-commissioning process and accelerating the lighting conversion to LED fixtures

5. Retro commissioning is an activity which will combine work to restore existing systems to their original intended performance and upgrade of the controls and sequences. In addition to energy savings, the benefits of recommissioning include extended equipment life, improved comfort and reduced operation and maintenance costs. Various studies show that the costs of retro-commissioning activities range from $0.13 to $2.00 per square foot, while payback ranges from 0.2 to 2.1 years. TDSB prefers to a more conservative approach and targets a retro-commissioning cost payback in the 6-7 years.

6. Lighting conversion to LED shall be accelerated, now that TDSB has firmed up its design guidelines and the technology prices are coming down.

7. We continue to expect the majority of the savings to come from gas-related applications. Savings in hydro usage achieved by using new technologies, BAS enhancements and lighting retrofits will likely be offset by the continuance of air conditioning expansion. The success criteria in achieving hydro savings shall be maintaining an even level of usage during the next reporting period.

8. The use of renewal energy equipment will likely not expand. The Board has covered almost every section of its roofs with solar panels. Wind turbines are controversial and are not a consideration at the moment; neither are applications such as solar walls or thermal solar panels.

9. As noted in this report, only 35% of the energy savings achieve by the Board in the last 5 years can be directly traced to major renewal work; the rest is tied to accumulated small maintenance activities and enhanced awareness of the need to conserve energy. Efforts by Operations/Maintenance Departments and Sustainability Office will continue in this respect.

A. <u>Future Energy Conservation Goals</u>

Typically, as any organization adopts a sustained program of measures to reduce its energy intensity, it becomes progressively harder to maintain a constant reduction pace, since eventually, a majority of energy conservation measures are planned and implemented.

However, the TDSB is still far from reaching the point where achieving a sustained rate of 5% energy intensity reduction is difficult to achieve. We therefore set this as the target for the next reporting period. The Board has set out the following energy intensity reduction conservation goals for the next five fiscal years.

Table 15: Annual Energy Intensity Conservation Goals

Annual Energy Intensity Conservation Goal	Benchmark	Fiscal Year 2018 to 2019	Fiscal Year 2019 to 2020	Fiscal Year 2020 to 2021	Fiscal Year 2021 to 2022	Fiscal Year 2022 to 2023
ekW/m^2	233.91	231.57	229.25	226.96	224.69	222.44
Percentage Decrease		1%	1%	1%	1%	1%

The following table shows the Board's Cumulative Energy Intensity Conservation Goal for the next five fiscal years.

Table 16: Cumulative Conservation Goal

Cumulative Conservation Goal	Fiscal Year 2018 to 2019 through Fiscal Year 2022 to 2023
ekWh/m^2	57.35
Percentage Decrease	5%

NOTE TO READERS:

There are many factors that influence a board's ability to meet energy conservation goals. A list of some of these factors include, but are not limited to, in the following changes:

1. Changes in Programming

   For example:

   - Introduction of Before and After School Programs to schools meant that the number of hours that a facility's HVAC system operates daily was expanded by four or more hours per weekday to reflect the longer occupancy hours.

2. Changes to the Ontario Building Code

   For example:

   - Regular changes/updates to the Ontario Building Code can impact energy use. For example, an increase in levels of ventilation in newly constructed buildings or other requirements. As a result, more fresh air is brought into a school to meet the ventilation requirements throughout the day requires heating and cooling of the air (dependent on the season) to meet standard classroom temperatures.

3. Changes to School Board Funding Models

   - Forecasted Conservation Goals are based on current funding models being in place throughout the next five years.
   - All boards' funding is determined on an annual basis. Any changes to the funding model will impact forecasted values.

4. Changes in Technology

   - Forecasted Conservation Goals are based on current technologies and related energy savings. If new technologies become available, anticipated energy savings may increase.

B. Environmental Programs

In Fiscal Year 2018 to 2019, schools within the Board participated in environmental programs.

1. Eco Schools:
   332 number of schools participate
2. Earth Care Schools:
   ___ number of schools participate
3. Enbridge: The School Energy Challenge
   2 number of schools participate
4. Other: The School Energy Challenge
   The name of the program is ____________________
   ___ Number of schools participate

C. Energy Efficiency Incentives

1. The Board applies to incentive programs to support the implementation of energy efficient projects on a regular basis.

☒ Yes ☐ No

If yes, between Fiscal Year 2013 to 2014 and Fiscal Year 2017 to 2018, the Board has applied for $569,552 in incentive funding from different agencies to support the implementation of energy efficient projects at 142 locations.

2. The Board uses the services of the sector's Incentive Programs Advisor (IPA).

   ☒ Yes ☐ No

D. Energy Procurement

1. The Board participates in a consortia arrangement to purchase electricity.

   ☒ Yes ☐ No

   If yes,

   ☒ OECM's Strategic Electricity Management and Advisory Services
   ☐ Other:
   Provide Name of Consortia: ____________________

2. The Board participates in a consortia arrangement to purchase natural gas.

   ☐ Yes ☒ No

   If yes,

   ☐ Ontario Education Collaborative Marketplace's (also known as OECM) Natural Gas Management and Advisory Services
   ☐ Catholic School Board Services Association' (also known as CSBSA) Natural Gas Management and Advisory Services
   ☐ Other:
   Provide Name of Consortia: ____________________

E. Demand Management

1. The Board uses the following method(s) to monitor electrical Demand:
   - ☒ Invoices
   - ☒ Real-time data
   - ☐ Online data from the Local Distribution Company (LDC)
   - ☐ Other:

   ____

2. The Board uses the following methodologies to cut down electrical demand:
   - ☒ Equipment scheduling
   - ☒ Phased/staged use of equipment
   - ☐ Demand-limit equipment
   - ☒ Deferred start-up of large equipment (e.g. chiller start-up in spring)
   - ☒ Other:

   Lighting LED upgrades, VFD devices, magnetic bearing compressors

F. Senior Management Approval of this Energy Conservation and Demand Management Plan

I confirm that Toronto District School Board senior management has reviewed and approved this Energy Conservation and Demand Management Plan.

Full Name: **Steve Shaw**

Job Title: **Executive Officer, Facilities and Planning**

Date: **July 23, 2019**