MINIMUM BACKUP POWER GUIDELINES FOR MURBs

VOLUNTARY PERFORMANCE STANDARDS FOR EXISTING AND NEW BUILDINGS

If you have comments or questions please direct them to:

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INTRODUCTION

This guideline discusses a number of opportunities to help improve resilience to area-wide power outages in multi-unit residential buildings (MURBs), both existing and new. It is based on a study completed by the EED in collaboration with the Hidi Group, which included business cases for several representative MURBs. Based on the results of this study, key opportunities for strengthening resilience are:

- Powering essential loads beyond life safety requirements, such as additional elevators, domestic water pumps, and common areas;
- Ensuring backup power provision for at least 72 hours; and
- Using natural gas generators.

As Torontonians are living in taller buildings and as extreme weather events are expected to increase in frequency and severity, improving backup power in MURBs will strengthen the city's overall resilience by allowing people to remain in their buildings during area-wide power outages. This will provide safety and comfort, especially to vulnerable populations, and may potentially reduce added demand on public services, infrastructure, and facilities during non-emergency situations.

Note: *The objective of this guideline is not uninterrupted power for care occupancies (e.g. long-term care facilities, hospitals). This guideline aims to identify financially viable practical solutions to extend the scope of emergency generators and other strategies to provide essential backup power to residents of MURBs in the event of area-wide power outages such as those caused by the 2013 summer rain storm and winter ice storm.*

Emergency Power vs Backup Power

Emergency power is provided to meet minimum life safety requirements, which specify 2 hours of power supply to facilitate occupant evacuation and firefighter access. Current codes and standards for emergency power in MURBs were written largely as a response to a series of fires in the late 1970s, but have changed very little over the last 30 years. During sustained area-wide power outages, emergency power is not designed to keep residents in their buildings with any degree of comfort, even if there is no particular problem with the building.

However, backup power is provided to meet non-life safety requirements that are considered essential for occupant well-being (e.g. water supply, heating, elevators), such that occupants can remain in their building safely and with a degree of comfort for at least 72 hours.

Purpose of the Guideline

There is no current code or standard that addresses sustained, area-wide power outages in MURBs, during which there is no emergency in the building. In other words, although high-rise buildings are mandated to have on-site generators and supporting electrical distribution, policy has not evolved to have these systems reconfigured to also provide a basic level of back-up power for residents to remain in their buildings during power outages.

The guideline also reflects emerging policy in the City of Toronto Official Plan as well as proposed changes to the Growth Plan for the Greater Golden Horseshoe. Both documents speak to addressing the impacts of climate change, including building more resilient infrastructure and communities.

Toronto Hydro, following an independent review of their performance during the ice storm, is also planning to engage with the province and the City of Toronto to address backup power needs in buildings, in particular to:

1. "Accommodate the safe evacuation of occupants;

2. Assist firefighter operations; and
3. Provide emergency power supply to meet essential needs (e.g., refrigeration, heat, phone service) during an extended outage."

Finally, some developers and property managers have already recognized the value of resilience and are beginning to implement solutions. This guideline will help others begin to consider opportunities for their own buildings.

Application of the Guideline

The guideline is voluntary and would apply city-wide with an emphasis on high-rise MURBs. However, given that MURBs over six storeys require a generator, the guideline would also apply to most mid-rise MURBs as well.

The performance standards in the guideline generally apply to both existing and new MURBs, although certain standards are more specific to existing buildings and others to new buildings.

For more information

This performance standards in this guideline are based on a study of backup power opportunities for MURBs, which includes business cases for several types of existing and new buildings. The report also contains background information on the electricity distribution system and a brief history of major power disruptions, the evolution of emergency power systems, including codes/standards and design practice, and an introduction to the concept of resilience.

The next section provides some context for existing and new MURBs in Toronto, including general characteristics relevant to backup power. Following that are the performance standards, which include estimated costs based on the business case analyses. Also included in this section are brief case studies of buildings that showcase examples of some of the performance standards.

PERFORMANCE STANDARDS

Essential loads in addition to life safety requirements

Minimum life safety requirements are based on the assumption that there is an emergency (i.e. fire) in the building, so the emergency power system is designed to facilitate occupant evacuation and firefighter access. However, during a non-emergency situation such as an area-wide power outage, evacuation is unnecessary and possibly harmful. Unfortunately in these situations an emergency power system designed to minimum code is not suitable to keep residents in their buildings for sustained periods of time.

Non-life safety requirements, while not mandatory, can be considered essential for occupant well-being and comfort during sustained power outages. For example, water supply to units, access to an elevator, and minimum levels of space heating/cooling and power. Backup power systems provide these services and thereby allow residents to remain in their building safely and with a degree of comfort for at least 72 hours.

1. Elevators

At least one elevator, in addition to the firefighter's designated elevator, should be backed up for resident use during a power outage.

Minimum standards for emergency power specify the provision of at least one elevator for firefighter access, but residents cannot use this elevator during a power outage even if there is no emergency in the building. It is essential, especially as MURBs continue to increase in height, that residents are able to use an elevator.

For both existing and new building, backing up a second elevator for resident use can cost $20-25,000, less than 10% of total project costs. However, costs decrease for additional elevators such that a third would only cost an additional $10,000.

2. Sump pumps

Sump pumps in basements should be backed up to ensure that any water entering below grade, such as during a rainstorm, can be pumped out during a power outage.

Backing up sump pumps costs an average of $8,500 and $10,000 for existing and new MURBs, respectively, which is undoubtedly less than the costs to clean up a flooded basement and/or replace its contents. In both cases, this amounts to less than 5% of total project costs.

3. Domestic water booster pumps

Backing up booster pumps is necessary to provide adequate water supply to units, especially units located above the fourth floor. Water for drinking, washing, and flushing toilets is essential during extended power outages.

The cost to back up domestic water booster pumps in existing and new MURBs is approximately $10,000 and $15,000 respectively, both less than 5% of total project costs.

4. Hot water boilers and pumps

Ensuring hot water circulation is an important aspect of asset management as it would help preserve the integrity of pipes during power outages in the winter. Additionally, it would ensure greater occupant comfort during sustained power outages by making showering and dishwashing easier.

Boilers and hot water pumps can be backed up for approximately 5-10% of total project costs. A standard natural gas boiler is actually a very small load, but the pumping requirement can be significant, especially in tall buildings. The average cost for both existing and new MURBs is approximately $50,000.

5. Space heating

Units in MURBs with radiant heating, which tend to be older apartment buildings, can be provided with space heating at a low incremental cost because it only requires providing backup power to the boiler and pumps, similar to the previous example. However, units with heating systems like fan coils or heat pumps – more typical of newer condominiums – are unlikely to have space heating because each individual heating system would require backup power. The additional electrical distribution costs to each unit tend to make this approach cost-prohibitive.

The average $50,000 cost to backup boilers and hot water pumps provides substantial additional value to residents of units with radiant heating as they may not necessarily need to leave their unit during winter power outages.

Providing space heating (as well as cooling and some convenience electricity) to a common area such as a lobby or party room, is the preferred approach in a scenario where it cannot be provided to individual units. The concept of a "common refuge area" is explained below.

6. Common refuge area

Common refuge areas are shared spaces where residents can gather to stay warm, charge cell phones, and perhaps prepare a meal, for example. This is a key resilience solution in situations where it is cost-prohibitive to provide heating to individual units.

Common areas in existing and new MURBs can be provided with minimum levels of space heating/cooling, as well as lighting and power, for approximately 5% of total project costs. The requirements for additional HVAC equipment and electrical distribution are minimized by limiting improvements to a single shared space.

Providing these services to individual units can be cost-prohibitive. The electrical distribution costs and generator capacity required, which can easily double, can increase total costs by over 50%. However, backing up a common area for residents to share provides the economies of scale to make it cost-effective. The average cost is $25,000 and $30,000 for existing and new MURBs, respectively, but the value is significant. In addition to keeping warm/cool, residents can charge cell phones, store medicine and perhaps prepare food.

Given occupancy limits in common areas, property management will likely have to coordinate access through an operational protocol. The intent is that the common refuge area is used on a temporary basis to access services not available in one's unit.

7. Coordinate electrical distribution work in existing MURBs

When considering adding a new generator or replacing an existing one in a building without separated loads, coordinating with other electrical work can help reduce electrical distribution costs, for both life safety and non-life safety loads.

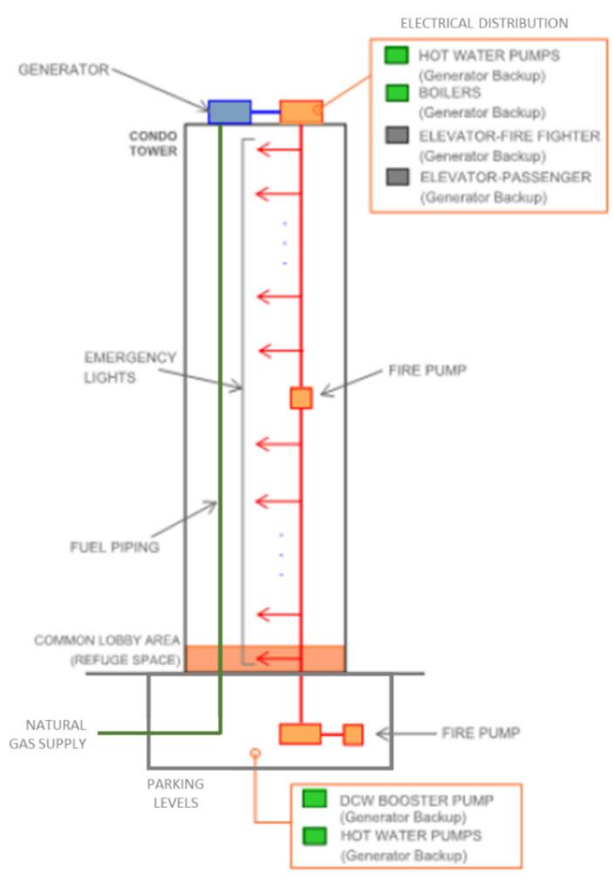
Electrical distribution costs in existing MURBs, whether designed for life safety loads only or to connect additional non-life safety loads, can range from 20-30% of total project costs given the complexity of such a retrofit. There may be cost savings available if this work can be undertaken at the same time as other planned electrical work.

8. Consider opportunities to provide backup power to at-grade spaces in new MURBs

If at-grade spaces are anticipated to host important community services, consider designing the backup power system to also provide backup power to this part of the building.

There may be situations where a MURB developer knows in advance that the at-grade space will be occupied by a particular tenant with a need for backup power. Although different uses of the space will have different backup power needs, costs will be significant given increased generator capacity and electrical distribution requirements. However, it would be much more cost-effective to include this ahead of time with designs for the entire backup power system, including the residential component.

See the schematic below for an example of a MURB with backup power to non-life safety, essential loads.



CASE STUDY: ONE BLOOR

This 76 storey, 732 unit building, currently under construction at the southeast corner of Yonge & Bloor, includes several features that improve its resilience to power outages.

Additional loads

- Domestic water booster pumps
- Sump pumps
- Additional elevators for residents
- Boilers and hot water pumps
- Certain amenity areas in within the first six floors will have some power

Generators

The building will rely on natural gas generators for backup power, but also includes diesel units in case there is a natural gas disruption.

Operations

Property management staff will be fully aware of the capabilities of the backup power system and will be responsible for informing residents of protocol during a power outage.

1 Bloor Street East

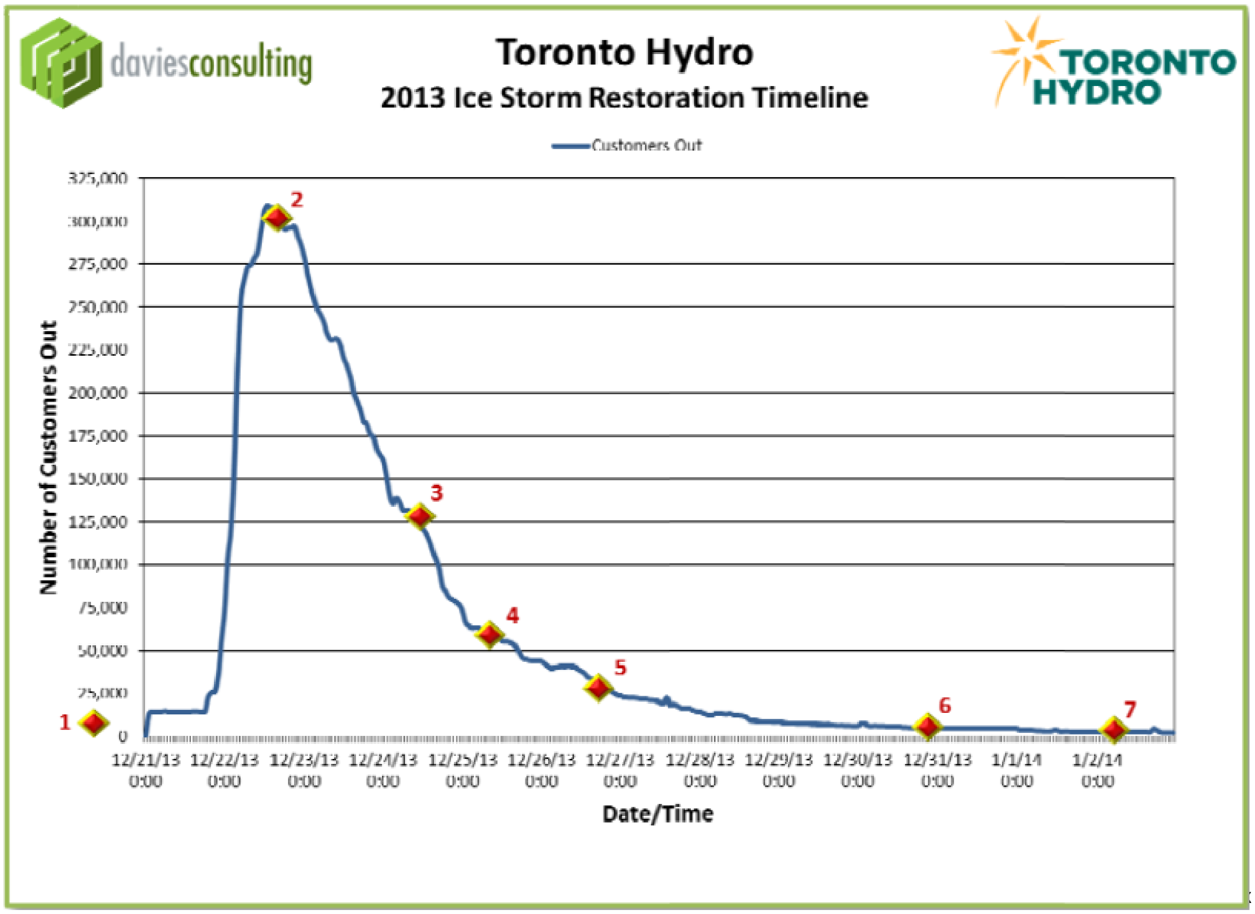
Image: https://commons.wikimedia.org/wiki/File:NumberOneBloorConstruction.jpg

72 hours of backup power

Backup power systems should be capable of providing power to essential services for at least 72 hours without requiring refuelling. During area-wide power outages, MURBs are at risk of not getting refuelled given the needs of other critical facilities such as hospitals. Even if refuelling services are available, extreme weather may make it difficult to access these services.

Surveys of residential property managers in Etobicoke Centre and Scarborough Centre found that power outages during the 2013 flood and ice storm lasted up to 72 hours. Although most buildings were able to sustain emergency power throughout the disruptions, many required refuelling. In some instances, especially during the ice storm, refuelling services were unavailable and some buildings were without power for a period of time.

The graph below is based on data from the 2013 ice storm and it indicates that it took Toronto Hydro approximately 72 hours to restore power to 86% of the customers who were without power at peak.



72 hours is also the general emergency preparedness standard advocated for by the City of Toronto Office of Emergency Management, Toronto Hydro, and the Government of Canada. Each of these organizations suggests having a 72-hour emergency preparedness kit on hand.

9. Design for 72 hours of backup power

In a scenario where re-fuelling services may not be available for MURBs (i.e. during an area-wide power outage), a diesel tank would need to be sized to store enough fuel for 72 hours of continuous operation, while a natural gas supply line would only need to be sized to provide the appropriate pressure to the engine.

In older MURBs without a generator or where a generator and associated equipment requires complete replacement, the ability to provide 72 hours of backup power depends on the availability of physical space. Overall costs are similar when comparing diesel to natural gas – generator costs are similar so it is essentially the cost of fuel handling equipment versus a pipeline. Available space for a new/larger fuel tank may favour a diesel system, but space constraints would favour natural gas.

New MURBs would have no issue being designed for 72 hours of backup power. However, in taller buildings and/or those with large generators, a diesel tank and pumps could end up requiring a significant amount of space.

CASE STUDY: 41 MABELLE AVE.

This 19-storey Toronto Community Housing building in Etobicoke, constructed in 1978, lost grid power for 36 hours following the July 2013 rain storm.

The existing diesel generator powered all emergency systems, as well as elevators and the recreation room. Residents congregated in the air-conditioned recreation room and were given drinks and snacks.

The building also fared well after the ice storm later that year even though the power was out for approximately 72 hours.

41 Mabelle Avenue
Image: http://www.storefronthumber.ca/housing/

Natural gas generators

Natural gas generators are preferred for backup power systems for several reasons, in particular their reduced operational emissions, simpler maintenance, and critical to resilience, the fact that no refuelling is necessary.

Although natural gas engines tend to be more expensive than diesel units as they increase in size, the liquid fuel handling systems for diesel units also become larger and the costs tend to even out.

Larger natural gas generators need load management systems in order to be able to meet the code-required 15 second start up time for emergency loads. While this equipment adds costs, it also allows for selection of loads to power, which can reduce the required generator size and cost.

Packaged, 400 kW natural gas-fired generator.

10. Use natural gas, especially in tall buildings

Not only are residents in tall buildings more vulnerable during power outages given their reliance on power for water and elevator use, but costs for diesel and natural gas systems even out as buildings get taller.

Natural gas engines cost approximately 15% more than diesel units, increasing to around 20% more as the engines increase in size. However, diesel fuel handling systems (tank, piping and pumps) get increasingly more expensive as buildings increase in height and total costs tend to even out.

11. Design load management systems with load selection capability

To help mitigate the cost of a load management system, which can be upwards of $100,000, design it so that it can choose which loads are required, which would help reduce the required size and cost of the generator.

Above 400 kW, natural gas generators usually require load management systems because the generator is unable to power all required loads immediately – in other words, loads must be added sequentially. Although load management systems add cost to the backup power system, they also allow for load selection. This could potentially allow for reductions in the generator size because certain equipment would not be operated at the same time others. For example, while the fire pump would be needed during a fire, it would not be needed during an area-wide power outage.

CASE STUDY: EAU DU SOLEIL

The Eau du Soleil development is two towers of 66 and 49 storeys currently under construction on the Etobicoke waterfront.

On the consultants' recommendation, the developer opted to use natural gas generators. Instead of one large generator, 4 or 5 smaller ones are being used in order to reduce costs and provide some redundancy – if one fails there is still some available power.

Natural gas was also preferred because the engines are quieter, cleaner and easier to operate. Avoiding the fuel handling equipment associated with a diesel system decreased the overall complexity of the design and saved space.

The small cost premium associated with a natural gas system is far outweighed by the benefit of uninterrupted operation during a power outage.

2183 Lakeshore Boulevard West

Image: http://urbantoronto.ca/database/projects/eau-du-soleil-condos

ADDITIONAL RESOURCES

Get Emergency Ready: High-rise Living (City of Toronto, Office of Emergency Management)
http://www1.toronto.ca/City%20Of%20Toronto/Office%20of%20Emergency%20Management/Files/pdf/O/OEM_HighRiseGuide.pdf

Are You Ready? How to Prepare Your Family for an Emergency (Toronto Hydro)
http://www.torontohydro.com/sites/electricsystem/PowerOutages/Documents/Updated%20Emergency%20kit%20Guide%20-%20April%202016.pdf

Your Emergency Preparedness Guide (Government of Canada, 2012)
http://www.getprepared.gc.ca/cnt/rsrcs/pblctns/yprprdnssgd/yprprdnssgd-eng.pdf

Status of Recommendations from December 2013 Ice Storm Report (Toronto Hydro, June 2015)
https://www.torontohydro.com/sites/corporate/WorkingWithTheCity/Documents/Status%20of%20Recommendations.pdf

Energy Consumption Trends of Multi-Unit Residential Buildings in the City of Toronto (Binkley, C., Touchie, M. and Pressnail, K., 2013)
http://towerwise.ca/wp-content/uploads/2013/07/TAF-MURB-Energy-Performance-Report-Phase-II.pdf

Official Plan Environmental Policies (City of Toronto, 2015)
http://www1.toronto.ca/City%20Of%20Toronto/City%20Planning/Environment/Files/pdf/ESA/OPA%20262%20Environmental%20Policies%20and%20Designation%20of%20ESA%20Areas%20BL%20No.%201158-2015.pdf

Proposed Growth Plan for the Greater Golden Horseshoe, 2016 (Government of Ontario, 2016)
https://www.placestogrow.ca/content/ggh/Proposed%20Growth%20Plan%20for%20the%20Greater%20Golden%20Horseshoe-2016.pdf

"Tower Neighbourhood Renewal in the Greater Golden Horseshoe: An Analysis of High-Rise Apartment Tower Neighbourhoods Developed in the Post-War Boom (1945-1984)" (E.R.A. Architects, planningAlliance, and the Cities Centre at the University of Toronto for the Ontario Growth Secretariat, Ministry of Infrastructure, November 2010) http://cugr.ca/pdf/TNR_GGH.pdf

How Does the City Grow? Revised June 2015 (City of Toronto, 2015)
http://www1.toronto.ca/City%20Of%20Toronto/City%20Planning/SIPA/Files/pdf/H/HDCG_Final_Revised_accessible.pdf

Avenues & Mid-Rise Buildings Study (Brook McIlroy Planning + Urban Design/Pace Architects with E.R.A. Architects, Quadrangle Architects Limited, and Urban Marketing Collaborative. May 2010)
http://www1.toronto.ca/City%20Of%20Toronto/City%20Planning/Urban%20Design/Mid-rise/midrise-FinalReport2.pdf

Yonge St. corridor can't handle more development (Toronto Star, July 6, 2016)
https://www.thestar.com/opinion/commentary/2016/07/06/yonge-st-corridor-cant-handle-more-development.html

Ontario Population Projections Update, 2015-2041 (Government of Ontario, 2015)
http://www.fin.gov.on.ca/en/economy/demographics/projections/

APPENDIX: MURB ARCHETYPES

Existing Buildings

From the perspective of opportunities and challenges pertaining to improving backup power in existing buildings, Toronto's current MURBs stock can be grouped into three categories:

- The Post-WWII period, from the mid-1940s through 1970s, characterized by high-rise apartment towers constructed throughout the inner suburbs
- The early, city-wide condominium booms of the 1980s and 1990s, tempered by recessions in the early part of each decade
- Sustained development since the early 2000s, characterized by signficant high-rise condominium development Downtown and in the Centres, as well as increasing mid-rise development along the Avenues

Toronto's current stock of MURBs (5 storeys or more) was most recently estimated at 2,100 total buidlings – 1,610 high-rise and 490 mid-rise – based on data up to 2010. Factoring in completions since that time, but eliminating buildings less than 7 storeys that do not require a generator, would put the current total (over 6 storeys) in the range of 2,000 to 2,500. The City of Toronto estimates that 1,189 of these buildings (greater than 7 storeys) were constructed between 1945 and 1984.

Mid-1940s through 1970s

Before emergency power requirements became common in the late 1970s/early 1980s, many of Toronto's MURBs were built without generators, in which case fire pumps would be operated by standalone diesel engines. They likely have battery packs to provide emergency power to smoke detectors, fire alarms, and lighting. In the case that a building from this period does have a generator, it is likely diesel-fuelled and designed to power life safety loads only. Furthermore, the generator is likely in need of replacement if it has not been already.

Jane-Exbury Towers

Image: http://www.michaeld.ca/downsview/Jane_and_Wilson.html

For existing buildings without a generator or with a generator that requires replacement, there is an opportunity to provide backup power at a reasonable cost, especially if project work can be coordinated with other state of good repair work.

In older MURBs the most significant cost is the electrical work required to connect new loads, which can be in the range of 20-30% of total project costs whether life safety or non-life safety loads. However, this cost is similar for any level of resilience – in other words, powering additional loads would not change the electrical distribution costs significantly. Therefore, existing building owners that have already decided to install a new generator can dramatically improve the resilience of the building for a small marginal cost.

For example, since many of these buildings likely utilize radiant heating, backing up boilers and hot water pumps can provide space heating to individual units at a low cost.

1980s and 1990s

From the 1980s onwards, most MURBs would have been required to have a generator for emergency power. Similar to older MURBs however, they are likely diesel-fuelled and only power life safety loads. Generators from the 1980s and early 1990s may be approaching end of life and require replacment.

MURBs from this era are very similar to older MURBs in the context of improving backup power. However, as these buildings began to be designed for energy efficiency, in-suite heating moved to heat pumps or fan coils (i.e. not radiant). Also, common areas and amenity spaces in new condomoiniums became more prevalent.

Although it may therefore become cost-prohibitive to provide space heating to indvidual units in these buildings, common areas can be backed up to provide a temporary place of refuge during power outages.

44 St. Joseph Street

Image: http://mediatours.ca/408-44-st-joseph-street-toronto/

Early 2000s onwards

Any MURB built since the late 2000s would have a generator for emergency power. Although it would likely still be in good working condition, diesel-fuelled, and only power life safety loads, it is also likely that the electrical system would be designed with separate circuits for life safety and non-life safety loads given the change in industry practice following the 2003 blackout. This load separation was codified in the 2009 version of the Ontario Electrical Safety Code and the majority of newer MURBs would comply with this.

City Place

Image: http://www.cbc.ca/news/canada/toronto/cityplace-condo-community-plans-new-schools-daycare-1.3144970

Individual loads, particularly pumps, tend to increase with building height, so backing up equipment can be more costly compared to older buildings. However, since life safety and non-life safety loads are likely already separated, the overall costs would be lower.

Common areas and amenity spaces became increasingly prevalent during this time, which creates an opportunity to provide more refuge space in these buildings. This is important considering the costs associated with providing even minimum levels of space heating or power to individual units.

New Buildings

Recent proposals for new MURBs are dominated by high-rise condominium buildings, primarily Downtown, but also within the Centres and at certain transit nodes. Mid-rise propsals are becoming increasingly prevalent along certain Avenues. Ultimately, Toronto is growing rapidly and more relevant to backup power, growing vertically.

The development pipeline from 2010-2014 includes over 195,000 residential units. 40% of these are proposed for Downtown and the Central Waterfront, 9% for the Centres, and 22% for the Avenues. Mixed Use Areas and other areas are expected to absorb the remainder. Over 45% of these units have been approved and issued building permits.

Overall population is also expected to grow rapidly from 2.83 to 3.74 million city-wide by 2041. The Downtown population is expected to almost double from approximately 250,000 to 475,000 people. The Avenues are estimated to be able to accommodate 250,000 new residents. The Yonge-Eglinton Centre might see an additional 20,000 people on top of the 24,000 expected once current developments are completed.

Any MURB over 6 storeys proposed today would be required by code to have a generator for emergency power. Diesel tends to be the default fuel, although natural gas use is increasing. In addition to meeting life safety requirements, current industry standard practice includes powering sump pumps, domestic waer booster pumps, and in some cases boilers/hot water pumps. Therefore, the electrical distribution systems in new MURBs are often already designed with separate circuits for life safety and non-life safety loads.

For energy efficiency reasons, most new MURBs would have in-suite heating systems (i.e. fan coils or heat pumps) and would be tightly sealed to prevent air penetration from corridors. As a result, providing space heating to units would be cost-prohibitive or ineffective (i.e. indirectly from corridors). However, most new MURBs have multiple and/or large common areas that can serve as temporary places of refuge.

Also prevalent in most new condominiums are at-grade commerical spaces. Some of these spaces host medical clinics, social services offices, and other instituional uses. It may be desirable to ensure that these spaces have backup power in order to continue operation during power outages.
New MURBs offer certain advantages compared to existing MURBs when it comes to improving resilience. Whereas adding non-life safety electrical distribution circuits to an existing building can be upwards of 30% of total project costs, it is closer to 10% when incorporated into new building design.

High-rise proposal at Yonge and Eglinton

Image: http://urbantoronto.ca/news/2015/01/yonge-and-eglinton-growth-watch-2015

The costs to backup loads in new MURBs tend to be slighlty higher compared to existing MURBs, but this is the result of the increasing building heights, which requires larger equipment (e.g. pumps). However, the costs to backup non-life safety loads remains a small percentage of total project costs.

Again, given the increasing heights and larger loads associated with new MURBs, generator size and costs increase as well. Natural gas engines cost approximately 15-20% more than diesel engines, but overall system costs are similar given the added fuel handling equipment needed for diesel systems.

For generators above 400 kW, load management systems must be added to natural gas systems and costs can be significant at around 10-15% of total project costs. However, the load management system can also be utilized to select which loads are required based on the circumstances, thus reducing the required size of the generator.

Mid-rise proposal on Kingston Road

Image: http://urbantoronto.ca/news/2015/07/slate-new-mid-rise-developments-transforming-kingston-road