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Parking Regulations for High Rise Buildings

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This report is being re-produced with permission from authors to help raise awareness about the impact of building design, built form, and regulatory standards related to parking on socio-economic outcomes in urban centres. This report is commissioned by Residential and Civil Construction Alliance of Ontario (RCCAO) and completed by Ryerson Urban Analytic Institute.

This report has been prepared by Yemi Adediji, Liam Donaldson, and Murtaza Haider. For related research, please visit: www.urbananalyticsinstitute.com.

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Executive Summary

Minimum parking standards impact built form, travel behaviour, housing affordability, and stormwater capacity. As mobility by private automobile became ubiquitous in Toronto and many other major cities, the need to provide ample and adequate parking space became a paramount planning consideration.

An article published on July 7, 1948, in the *Globe and Mail* focused on the increase in traffic to downtown Toronto from the suburbs. The newspaper reported that over 105,000 automobiles were headed to downtown where the parking lots could only hold 16,500 vehicles. The news item described the congestion in downtown Toronto as "Suffering Acres."

The postwar experience with traffic congestion in the urban core of Toronto resulting from an influx of automobiles arriving in downtown Toronto from the suburbs had an influence on minimum parking standards. Before the arrival of off-street parking, drivers parked vehicles on streets and inadvertently impeded traffic flow and exacerbated traffic congestion.

During the same postwar period, Metropolitan Toronto made significant progress in the provision of public transit, including higher order transit provided by the Toronto Transit Commission and regional rail (GO) provided by Metrolinx. Today, the majority of trips made to downtown Toronto in the morning peak hours is by public transportation. This has afforded the downtown core the ability to continue to grow to become Canada's largest employment hub without having the need to supply parking for nearly half a million commuters working in Toronto.

This report finds that Toronto's minimum parking standards have not been meaningfully revised in the past three decades. In addition, substantial changes in travel behaviour, technology, and services have taken place that necessitate a review of fundamental planning concepts and related parking standards. Further, the expected innovations in mobility, such as autonomous vehicles, will not only impact how people commute, but also how much parking space will be required in the future.

Already, ride-hailing and car sharing are having an impact on automobile ownership in the central parts of the City where public transit currently offers an essential mobility service. For residents of multifamily residential buildings that allow for car sharing options, there is reportedly a lower propensity to own automobiles. Although the City has responded to emerging trends by lowering parking requirements for residential buildings that provide car sharing facilities, such arrangements are limited to individual buildings and are implemented on a case-by-case basis.

Surface parking is disappearing in the urban core because of high land values, but autonomous vehicles (AVs) are likely to displace or further reduce parking requirements there. One planning theory suggests that because land is significantly more expensive in the urban core, provision of parking for AVs will therefore relocate to the periphery where land is cheaper. Fully autonomous vehicles will be capable of dropping the occupants in the urban core and then driving to remote and less expensive parking facilities. Similarly, AVs will be capable of parking themselves in a consolidated fashion such

that the space per vehicle required in a parking garage in the future will be much less than the space required today.

These types of scenarios point to a higher likelihood of lower automobile ownership and parking space requirements in the urban core in the future. Therefore, reviewing minimum parking standards for new high-rise buildings becomes an important planning consideration.

In addition to highlighting the need for a review of the minimum parking standards, this report further makes a case for above-grade parking in new high-rise developments. Continuing the current practice of below-grade parking imposes at least two immediate externalities. Firstly, underground parking, particularly in certain locations, has an adverse impact on stormwater capacity that creates significant health and safety problems. Secondly, the cost of constructing below-grade parking has increased rapidly over the past decade, with a current range of $80,000 to $100,000 in select downtown Toronto locations, with adverse impacts on housing affordability. In addition, minimum parking requirements increase development costs which also has a direct impact on total housing costs and overall affordability.

Provision of above grade parking is less expensive and at the same time allows for the repurposing of parking spaces if space becomes redundant in the future. The report presents examples of how new buildings have integrated and repurposed above-grade parking in cities like London, England, and Denver. However, to be able to repurpose floors dedicated to parking in the future, structures have to be designed differently to facilitate conversion from parking garages to other uses. The following are the key recommendations.

Key Recommendations:

1) **The City of Toronto must undertake a review and overhaul minimum parking standards to reflect the significant changes in travel behaviour, technology and services that have taken place over the last three decades.**

The minimum parking requirements for downtown Toronto have been largely unchanged since 1986. Changes in transportation technology and services, characterized by ride-hailing and car-sharing, and emerging technologies including various levels of automation necessitate a thorough review of Toronto's parking and related regulatory standards.

2) **The City of Toronto should examine and encourage innovative above-ground parking options that will facilitate the repurposing of parking space for other uses in the future.**

The evidence presented in this report suggests that automobile ownership is likely to experience modest declines in the future. Provisions should be made to ensure that building owners can repurpose parking spaces for more efficient use in the future as parking spaces become redundant.

Provision of underground parking does not permit repurposing in the future, making valuable property in the city underutilized based on other potential uses.

3) **City of Toronto should consider implementing more flexible parking standards rather than formula-based rigid parking requirements.**

A review of parking standards and regulations from other North American jurisdictions suggest that flexible parking standard regimes that are sensitive to local land uses, accessibility to public transit and travel behaviour are preferable to formula-based rigid parking requirements since these will allow for a more nimble approach to emerging technologies and changing demographic patterns.

Introduction

This report examines the impact of the emerging mobility trends such as car-sharing, ride-hailing and the impact of autonomous vehicles, on private automobile ownership, and in turn, on transportation amenities (e.g., parking facilities in high-rise buildings) that are likely to become less critical as a result.

Cities across North America and Europe are characterized by one or more economic hubs with a densely distributed mix of residential, commercial and other land uses, around which relatively less dense and mainly residential zones are located. Together, these economic centres and their surrounding residential zones make up geographic and economic regions with joint housing and labour markets, as well as other interdependencies. One of the important and enabling factors facilitating these interdependencies is transportation.

In most urban centres in North America, the primary mode of transportation has been the private automobile. Although automobile modal share has declined over time, especially for certain census metropolitan areas[1], still most motorized trips are made by cars. As such, transportation infrastructure, such as the regional network of roads and highways, and parking facilities continue to be important. One indication of the importance of parking in various North American regions is that minimum parking requirements are codified into zoning by-laws and ordinances, whereas, many cities have no corresponding maximum parking requirements. At the same time, public transit also contributes to serving the mobility needs in urban centres, especially for trips originating in or destined to downtown cores and surrounding nearby suburbs.

Determination of capacity for roads, highways and parking facilities is necessarily tied to demand. Thus, automobile ownership is considered an indicator of trip generation and parking demand. In the dense city centres, the focus in the past has been on getting cars through the street network with as little encumbrance as possible. This required moving on-street parking spots to off-street locations. This proliferated off-street parking either as underground or above-ground parking structures.[2]

The expected changes in the mobility culture and technology, such as car-sharing, ride-hailing, and autonomous vehicles, will impact the demand for automobile ownership and eventually parking facilities. The new trends in automobile ownership and mobility will, in comparison, have a lesser impact on highway and road capacity because travel demand is not expected to decline and hence the dependence on roads and highways is unlikely to subside in the future. Several studies have shown that car-sharing and ride-hailing are likely to increase the vehicle-kilometres-travelled by causing a modal shift from transit, and by generating trips from people who would not ordinarily drive such as the disabled and the

[1] Statistics Canada 2017
[2] Smith, Wilbur S 1984

elderly.[3] The increase in vehicle-kilometres travelled is also an expected impact of autonomous vehicles that may remain continuously in circulation and occupy roads for longer durations than the driver operated vehicles.[4]

The aforementioned developments in mobility technologies are likely to reduce automobile ownership. The corresponding reduction in demand for parking may also be advantageous. One advantage is likely to be an improvement in housing affordability, since supplying parking in residential developments, especially in high-rise residential buildings adds to the price of individual units. Five-year old data indicates that the average cost of a single parking spot in a high-rise residential building in downtown Toronto is upwards of $50,000.[5] More recent industry information shows that the construction cost per underground space is in the range of $80,000 to $100,000, depending on various site and building parameters, such as hydrogeological conditions, proximity to adjacent buildings, levels of below grade parking (e.g., five to six levels becomes more expensive), requirements for a raft slab and waterproofing. The cost of a parking stall is then recouped in the sale price of units.

This report is organized as follows. The report first examines automobile ownership in high-rise residential buildings in Toronto. The combination of high-rise residential development and a compact urban form yields relatively low automobile ownership rates compared with single-family attached and detached housing in suburban or rural settings. This section also discusses the impact of higher order transit, car-sharing, ride-hailing, and autonomous vehicles on automobile ownership in the Toronto context. The section presents evidence that both supports and challenges the notion that automobile ownership has been declining in Toronto.

The second section discusses the role of regulation in automobile ownership and parking. It further highlights current and future policy directions. The final section discusses innovative and adaptable residential and commercial development strategies that consider the potential future of automobile ownership and parking provision.

[3] Henao, Alejandro 2018
[4] Guerra, Erick 2016
[5] Bond, R. 2015

Automobile Ownership in Toronto High-Rise Residential Buildings

The private automobile is essential for economic growth and social integration in North America. It continues to be the primary mode of travel for work and other purposes for a substantial proportion of the urban labour force. A large proportion of work trips originating in outer suburbs and regions end up at work destinations in the urban core. The periphery to core trips increasingly rely on the private automobile. The latter half of the last decade has seen a decline in transit ridership in certain cities in the United States and Canada. Ridership declined in the U.S. by about six percent between 2014 and 2018[6] and has stalled in Canada since 2014.[7]

Transit ridership is typically the highest in trips originating in or destined to the urban core. Historically, the earliest transit services, offered in the form of streetcars played a large role in the development patterns we see today- with dense city centres and dispersed residential growth along transit lines.[8] Not long after the era of the streetcar, the popularization of the private automobile resulted in the spread of development beyond transit corridors, further decentralizing the city and expanding the geographic boundaries. The past development trends continue to impact the way we live and commute today since dense city centres and their transit corridors are still the focus of high development pressures. The city centres boast the highest transit use and the highest concentration of jobs.

The dense urban core surrounded by low-density suburbs is also true for the City of Toronto (Census Subdivision). Toronto is supported by rapid and light rail in its downtown core and is connected by commuter rail to the outlying regions. Compared to the other North American cities, Toronto has experienced marked success in increasing development density that is supported by transit. As a result, Toronto demonstrates development occurring in concert with transit expansion with the potential for greater flexibility and diversity in modes of transportation compared to many other North American cities, which primarily support an automobile-dependent lifestyle.

According to the Transportation Tomorrow Survey (TTS),[9] the Toronto downtown core is made up of mostly smaller-sized households that reside in mid- to high-rise apartment buildings, as compared to other municipalities comprising the Toronto Census Metropolitan Area (CMA) where most households live in single-family attached or detached housing. In 2016, 155,498 households owned between zero and four vehicles in Toronto downtown core. Of these households 145,928 lived in apartments or condominiums, 5,786 lived in townhouses, and 3,784 lived in single-family-detached households. Table 1 shows the automobile ownership break-down for these households.

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[6] Freemark, Y. 2018
[7] Spurr, B. 2018
[8] Vuchic, Vukan 1999
[9] Data Management Group 2016

Figure 1: Toronto's downtown core (TTS)

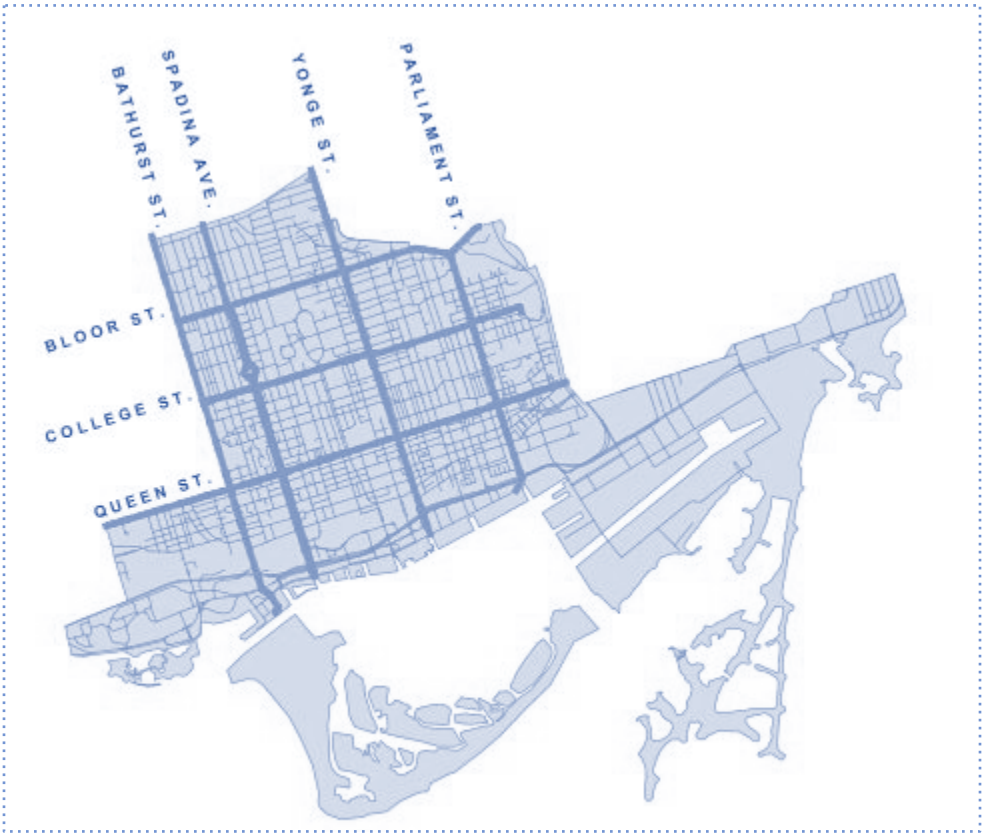

Table 1: Vehicle Ownership by Dwelling Unit Type, Toronto 2016

Vehicles	Single-family Houses	Townhouses	Apartments
0	26%	27%	53%
1	52%	58%	41%
2	18%	13%	5%
3	2%	1%	0%
4	1%	0%	0%

The TTS data shows that more than half the households in apartments owned no vehicles. This is significant because as mentioned above, most households in the Toronto downtown core live in apartment buildings. This is also in line with other observations that note that reliance on private automobiles is lower in dense city centres.[10]

To further illustrate this dynamic, Table 2 presents the modal share for work trips in various Toronto neighbourhoods (TTS planning districts, Figure 2).

[10] Vuchic, Vukan 1999; Smith, Wilbur S 1984

Table 2: Mode of Travel for Work in Various Toronto Neighbourhoods[11]

PD	Auto (Driver)	Auto (Passenger)	Transit	Bicycle	Walk	Total
1	21%	2%	33%	7%	37%	100%
2	31%	3%	43%	12%	10%	100%
3	46%	6%	40%	3%	4%	100%
4	42%	4%	44%	3%	7%	100%
5	58%	7%	32%	1%	2%	100%
6	38%	5%	45%	7%	5%	100%
7	65%	4%	27%	2%	3%	100%
8	62%	5%	30%	1%	2%	100%
9	65%	10%	22%	0%	2%	100%
10	58%	8%	31%	0%	3%	100%
11	49%	4%	42%	1%	4%	100%
12	53%	6%	37%	0%	3%	100%
13	51%	7%	38%	1%	3%	100%
14	58%	6%	31%	1%	4%	100%
15	62%	8%	28%	0%	2%	100%
16	63%	9%	26%	0%	2%	100%

Notably, the downtown core of Toronto (PD 1) has the lowest share of work trips made by automobile. This is closely followed by neighbouring Districts 2 and 6. These three neighbourhoods also have the highest share of work trips made by walking. The outlying Toronto neighbourhoods (PD 7, 8, 9, 12, 13, 14, 15, 16) have the highest share of work trips made by driving.

The results presented here demonstrate that access to transit has resulted in relatively low automobile ownership in Toronto. However, one is still interested in changes in automobile ownership over time. Ryerson University's Centre for Urban Research and Land Development (CURLD) analyzed automobile ownership in the GTA and found that the share of zero-vehicle households has remained steady over the past three decades.[12]

[11] TTS, 2016

[12] https://www.ryerson.ca/cur/Blog/blogentry28/

Specifically, the study found that over the past three decades, automobile ownership in the central part of the City of Toronto (the urban core) has remained significantly lower than other remote or suburban parts of the City. The difference in automobile ownership between the core of the City, where the ownership is the lowest, and the suburbs, where the ownership is higher, has remained stable over time. This implies that the share of zero-vehicle households has not changed much over the past few decades. This is equally true for households living in the urban core. Despite the trends reported elsewhere about the decline in automobile ownership among younger cohorts, especially the millennials, the evidence presented in the Ryerson University study indicates that there has not been a marked departure in automobile ownership rates in the core of the City over the past three decades.

Figure 2: Location of Toronto Neighbourhoods

Two other surveys have examined automobile ownership in high-rise residential buildings in Toronto. One was conducted as part of a walkability study of Toronto's neighbourhoods in 2010, and another carried out in 2007 by Cansult Limited in preparation for the review of the City of Toronto's by-laws governing parking. We present a review of the two surveys in the following section.

2010 Walkability in Toronto's High-Rise Neighbourhoods Study

The study examined eight neighbourhoods in Toronto, including Chalkfarm, Kingston-Galloway/ Orton Park, North Kipling, The Peanut, St. James Town, Scarborough Village, Steeles L'Amoreaux, and Thorncliffe Park. Of these eight neighbourhoods, only St. James Town was within the downtown core of Toronto. The study sampled between 25 to 40 residents and collected such data as their opinions of the walking environment, safety issues, traffic and connectivity problems, and their method and ease of accessing shopping, work or

school. One major finding of this study was that 42% of the respondents lived in zero-vehicle households, while 43% lived in households where one vehicle was shared among several adults.[13] The study found that many respondents were dependent on transit and walking because of their circumstances. The high cost of automobile ownership results in lower automobile ownership and a greater reliance on public transit for mobility among low-income households.

2007 Cansult Ltd. Survey

The City of Toronto with Cansult Ltd. Survey parking requirements to determine vehicle ownership in Toronto in preparation for the review of zoning by-laws governing parking provision requirements. The goal was to inform the new zoning by-law 569-2013.[14] Cansult surveyed 1196 apartments and 3494 condominium households. Table 3 shows the results of the survey of condominium building residents. The results showed that the location of high-rise residential buildings and the unit size expressed as the number of bedrooms were key determinants of automobile ownership for condominium dwellers.

Table 3: Automobile ownership by the number of bedrooms for condominiums in Toronto[15]

	Bachelor	1bd	2bd	3bd+
Downtown Core	0.20	0.79	1.05	1.75
Downtown and Central Waterfront	0.75	0.73	1.11	1.32
Centres and Avenues near subway stations		0.90	1.17	1.35
Areas served by surface transit	0.50	0.92	1.14	1.10
Other		1.17	1.05	1.12

The results show a positive correlation between automobile ownership and the number of bedrooms. This may be reflective of the greater mobility needs of larger households relative to smaller households. The results also indicate that location is another factor affecting automobile ownership, with condominiums in the downtown core and central waterfront areas reporting lower automobile ownership rates.

The results of the 2010 Walkability Study and the 2007 Cansult Ltd. survey examined automobile ownership in Toronto high-rise residential buildings. The studies pointed to lower automobile ownership in Toronto's downtown core compared to other jurisdictions. Cansult Ltd. based their recommendation of minimum parking requirements on 65% of the average automobile ownership in downtown Toronto, and 95% in other parts of the City. A review of

[13] Hess, PM 2010
[14] Cansult 2007
[15] Categories with no entry had sample sizes that were too small for significant results

Toronto's minimum parking requirements, as per by-law 569-2013, shows that the minimum parking requirements are consistent with the Cansult Ltd. recommendations.

Toronto, as well as other large cities in North America, have adopted several innovative transportation processes and technologies with wide-ranging impacts on mobility. These include car-sharing, bike-sharing, and ride-hailing services, to name a few. While travel behaviour data indicates that most work trips are still made via the private automobile, there is a growing body of research that shows that certain demographic cohorts are choosing to defer automobile ownership or dispose of surplus vehicles. Most of these studies have examined dense city-centre areas, which are well served by higher-order transit. While the presence of viable transit alternatives influences the trends in automobile ownership or the disposal of surplus vehicles, innovations such as car-sharing and ride-hailing are also playing an increasingly important role.

The following section discusses the impact of car-sharing, ride-hailing, and autonomous vehicles on automobile ownership.

Car-Sharing in Toronto

Recent studies have explored the impact of car-sharing on vehicle ownership.[16] A review of these studies found that the proportion of car-share members that were able to give up a car as a result of access to car-sharing was as low as 6% in some studies and up to 32% in others, with the proportion of those who were able to forgo the purchase of a vehicle as low as 4% in certain studies and as high as 77% in others.

In 2009, IBI Group, sponsored by the City of Toronto, studied the impact of car-sharing services among those who lived in apartments and condominium buildings in Toronto.[17] The survey covered ten buildings with on-site car-share services and 43 buildings without. 27% of the units in each of the ten buildings were mailed a survey for a total of 992 units of a possible 3623. The response rate was 25%. The survey revealed that 29% of the residents who were car-share members gave up a vehicle after becoming members of a car-share service such as Maven or Zipcar. Another 55% of car-share members decided to forego the purchase of a first or second car as a result of access to car-share vehicles.

Overall, vehicle ownership was found to be 0.53 vehicles per unit for condominiums with car-share, which was significantly lower than 1.07 cars per unit in condominiums without the car-share facility. This difference does not entirely reflect the impact of car-share services in general because such services tend to target dense, walkable transit-rich areas, factors which already decrease the likelihood of residents owning vehicles, but it can be indicative of high-rise residential buildings in Toronto's downtown core since this was the environment studied in the survey. The report found evidence for minimum parking requirement reductions on-site

[16] Millard-Ball 2005; Shaheen 2009

[17] Engel-Yan, Joshua 2013; IBI Group 2009

at condominium buildings with car-share services. Table 4 summarizes the results of this study.

Table 4: Impact of car-share on vehicle ownership for condominium buildings in Toronto

Gave up the vehicle for car-share membership	29% of car-share members
Declined vehicle purchase for car-share membership	55% of car-share members
Car ownership at condominiums without car-share	1.07 per unit
Car ownership at condominiums with car-share	0.53 per unit

These results show that automobile ownership rates in high-rise buildings in Toronto could be lower with the introduction of car-sharing. Such societal changes in consumption will have implications for minimum parking requirements in centrally located high-rise buildings.

Based on this and other studies assessing the effects of car-sharing on vehicle ownership, IBI Group recommended reducing minimum parking requirements for condominium or apartment buildings by up to 4 parking spaces for each dedicated car share stall, a standard that has been codified in several by-law amendments for specific areas in Toronto, but not city-wide. The following are examples of such by-law amendments.

Table 5: Car-share parking by-law amendments for specific areas of Toronto

New By-law	Amended By-law	Affected Location	Provision
548-2017	438-86	700 Bay Street, 77 Gerrard Street West	A maximum of 3 car-share parking spaces shall be permitted, and each car-share parking space may reduce the minimum resident parking required by four (4) parking spaces
265-2017	438-86	18, 20, 22, 24, 26 and 30 Erskine Avenue	Parking spaces shall be provided and maintained on the site in accordance with the following minimum requirements: - Ten car-share parking spaces. - Notwithstanding the previous Section, the required parking spaces for residents shall be reduced at a rate of four parking spaces for each required car-share parking space on the site.
1364-2015	569-2013	661, 663, 669 and 677 Queen Street East, 77, 79 and 79A East Don Roadway	Parking spaces must be provided and maintained on the lot in accordance with the following: - A minimum of 5 auto-share parking spaces in a publicly-accessible location on the lot. - The required auto-share parking spaces may replace the parking spaces otherwise required for residential occupants, up to a maximum of 15 auto-share parking spaces.
569-2013 Amendment	569-2013	1182 and 1221 King Street West	On Block A: The required parking spaces can be reduced at a rate of 4 parking spaces for each car-share parking space, provided to a maximum of 5 car-share spaces on the lot. On Block B: The required parking spaces can be reduced at a rate of 4 parking spaces for each car-share parking space, provided to a maximum of 5 car-share spaces on the lot.

While Toronto has established by-law amendments to allow car share parking up to set maximums and to reduce private vehicle parking at residential buildings in specific areas, other cities in North America have implemented a bolder approach by allowing private vehicle parking reductions based on a prescribed amount of car-sharing parking provided

more comprehensively and city-wide. Examples include Seattle, which allows a parking requirement reduction by 2 parking spaces for each car-share space, and Vancouver, which allows a reduction by 5 spaces for each car-share space, with both cities having a maximum amount of car share spaces permissible.[18]

The 2009 IBI Group study found automobile ownership at high-rise residential buildings with car-share services in Toronto's downtown core to be about half the rate in high-rise residential buildings without car-share services. The findings that 29% of households with car-share memberships could dispose of their private vehicles, and that 55% could forgo the purchase of a first or surplus vehicle put the impact of car-sharing on automobile ownership in Toronto in line with the range found in other studies. Based on similar findings, the City of Toronto has implemented a reduction in minimum parking requirements in a small number of residential building sites.

Ride-Hailing in Toronto

The ride-hailing platform Uber has been operating in the City of Toronto since 2012. Reportedly, within a single year of operating UberX, Uber's largest service type, ridership was at 17,000 daily trips.[19] By 2016, ridership was estimated at 45,000 trips per day in Toronto alone[20], and to date, UberX continues to enjoy increasing patronage and public support[21], despite the problems faced by Uber and other ride-hailing companies, including challenges to the regulation of their operations, and safety issues. On May 3, 2016, the City of Toronto reached a resolution permitting the operation of private transportation companies in the City, effectively legalizing Uber. These regulations came into effect on July 15, 2016.

Uber has reportedly identified the private automobile as its main competitor, with a vision to reduce ownership. Travis Kalanick, the then CEO of Uber has remarked that the company's intention is to reach the level of efficiency at which the use of Uber is cheaper than owning a car. He further observed that "Uber doesn't grow if car ownership is cheaper than taking Uber."[22]

Currently, Uber and other similar services are far from being a substitute for private vehicle ownership, although they are making some headway. Comparative cost analysis shows that private vehicle ownership is less cost effective than the regular use of ride-hailing if one drives less than 9,480 miles per year.[23] A San Francisco-based study found a negative correlation between vehicle ownership and the use of ride-hailing.[24] Another study from

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[18] Engel-Yan, Joshua 2010
[19] Brail, Shauna 2018
[20] Moore, O. 2016
[21] Cook, T. 2015
[22] Shontell, A. 2015
[23] Hill, K. 2014
[24] Rayle, L. 2016

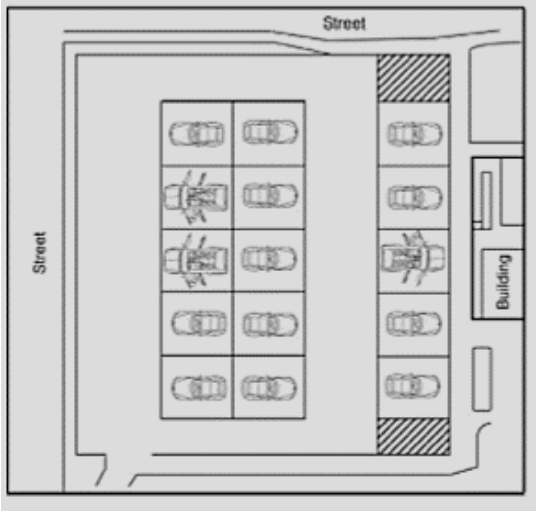
Austin, Texas, in the wake of the closing of Uber and Lyft operations, also found a similar negative correlation.[25] The ride-hailing operators ceased operations following the passage of a local law that mandated fingerprinting and background checks for drivers. The study found that after the exit of Uber and Lyft, 41% of respondents had shifted to a personal vehicle while 3% shifted to public transit. Additionally, 9% of respondents stated that they purchased a vehicle after the ride-hailing companies left.

Another study of over 4000 adults in major US metropolitan areas found that 21% of adults surveyed use ride-hailing services. Of those ride-hailing users, 39% were substituting for driving, 15% for public transportation, 23% for bicycling or walking, and 22% would not have made the trip without the option of ride-hailing.[26] A survey of the Denver region found that 13% of respondents reported deferring automobile ownership or disposing of owned automobiles due to ride-hailing.[27] The results also found that automobile ownership among those who used ride-hailing was significantly lower than the average for the region, at only 60% automobile ownership of those surveyed.

Autonomous Vehicles and Vehicle Ownership

The expected widespread adoption of autonomous vehicles (AVs) in the coming decades will significantly alter the design of parking facilities. Conventional layouts divide parking lots into islands that store vehicles in parking spots and roadways that enable vehicles to maneuver throughout the lot. Islands hold no more than two columns of vehicles in traditional designs. This ensures that no vehicle is prevented from entering or leaving a parking space.

Figure 3: Conventional Parking Lot Design



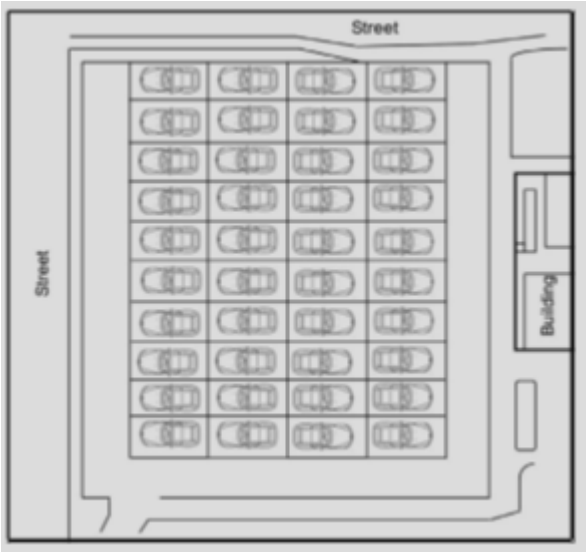
Source: Nourinejad, Bahrami & Roorda, 2018

With the advent of AVs, parking footprints can be reduced, and efficiencies increased. AV passengers can be dropped off at their destination or other designated areas and are not required to enter parking lots as AVs will park themselves. In addition, AV parking lots will require approximately two square metres less per vehicle than traditional parking lots, according to one study, as car doors will not need to be opened for passengers, elevators and stairs become unnecessary, and roadways become narrower.[28]

[25] Hampshire, R.C. 2018
[26] Clewlow, Regina R 2017
[27] Henao, A. 2018
[28] Nourinejad, Bahrami & Roorda, 2018

Unlike traditional parking lot designs, AV parking lots can have islands with more than two columns of vehicles. This increases parking space efficiency but can result in some vehicles being blocked from entering or leaving spaces by other vehicles. In these circumstances, blocking vehicles must be relocated, and the extent of relocation will depend on the layout of the parking lot. Optimal AV parking lot design should ensure that parking occupancy is high while vehicle relocation is low. Current guidelines for parking space dimensions, the orientation of spaces, and width of roadways do not consider possible AV movements within parking lots. Engineering and planning guidelines for parking lots will, therefore, need to be changed to accommodate AVs in the future.[29]

Figure 4: Autonomous Vehicle Parking Lot Design

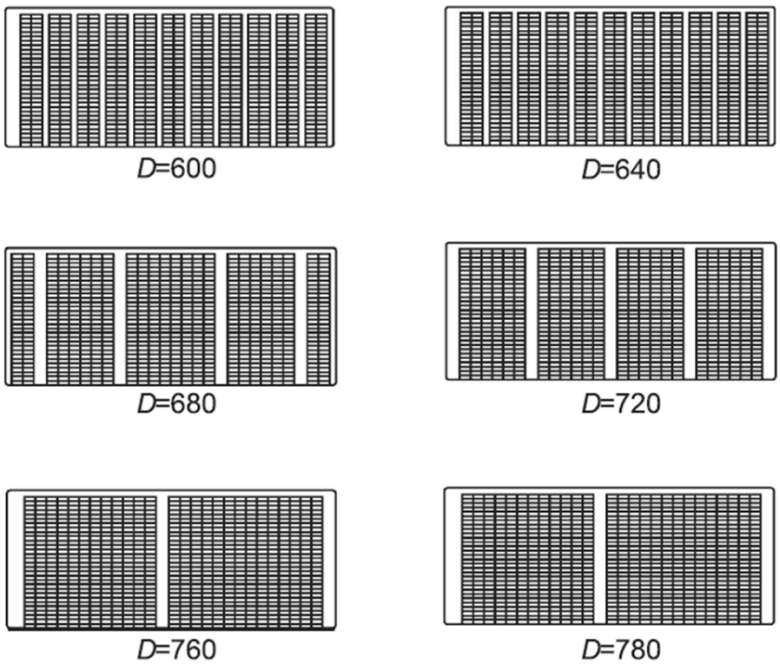


Source: Nourinejad, Bahrami & Roorda, 2018

Nourinejad, Bahrami & Roorda (2018) investigated optimal AV parking lot layouts for a given number of vehicles that minimize vehicle relocation. They consider a parking lot that is 150 metres long, 65 metres wide, and with roadway widths of 5 metres. Parking spaces in this scenario are 5 metres long and 2 metres wide, and there are 30 rows in each island. Parking demand ranges from 600 to 780 vehicles, and all cars are equal in size. When demand is low (e.g. 600 and 640 vehicles), islands have only two columns, similar to traditional parking layouts. This two-column design reduces the need for vehicle relocation. When parking demand is higher (e.g. 720, 760 & 780 vehicles) islands become larger with more columns. Two column islands are eliminated because the space needed to maneuver around them is more optimally used for parking. The authors found that AV parking lots can decrease the need for parking space by an average of 62% and a maximum of 87%.[30]

[29] Nourinejad, Bahrami & Roorda, 2018
[30] Nourinejad, Bahrami & Roorda, 2018

Figure 5: Optimal AV Parking Lot Layouts



Source: Nourinejad, Bahrami & Roorda, 2018

Nourinejad and co-authors suggest that subsequent AV parking lot design models consider individual vehicle characteristics such as arrival time, departure time, and vehicle size. In these scenarios, vehicles with earlier departure times would ideally be located at the outer edges of islands to facilitate faster retrieval. Their model also assumed constant and fixed parking demand where future models could respond to dynamic parking demand by changing the optimal layout throughout the day. This could result in an AV parking lot having different configurations in the morning, afternoon, and evening for example.[31] It should also be noted that these AV parking lot designs would only apply to open-air lots like those found at street level or on rooftops. Multi-level parking garages require load-bearing columns to maintain structural integrity (see Figure 6) which are not accounted for in the study.

[31] Nourinejad, Bahrami & Roorda, 2018

Figure 6: Underground Parking Garage Columns

Source: Bern Grush

Parking Requirement Externalities

Many cities in North America promote the construction of underground parking to protect the vitality of street activity and sense of place. Land-uses at the street level such as storefronts are often prioritized in accomplishing this goal. Above-grade parking structures, on the other hand, can interrupt street life because they take up street-level space that may be better used by retail and service land-uses unless a strategic design is used to incorporate such land uses. They, however, have certain advantages over underground parking, as the latter can have far-reaching externalities for housing affordability, stormwater management and other areas. We describe these in the following paragraphs.

Figure 7: Street-level parking entrance

[32]

Figure 7 above shows the entrance to an above-grade parking structure which creates a gap along the line of street-facing retail.

[32] Image taken from https://www.bestparking.com/new-york-ny-parking/neighborhoods/new-york-city-parking/

Housing Affordability

Ongoing review of parking policy is essential because policy outcomes have significant and wide-reaching impacts on quality of life. Toronto's parking policy has tangible impacts on housing affordability. The mandate to provide a minimum supply of parking for each high-rise residential building comes at a cost to City residents. Underground parking spots, usually offered for sale with condominium units cost around $50,000 to the condominium owner, with a construction cost of up to $100,000 per spot.[33] Part of this cost to supply parking at high-rise residential buildings is usually recaptured in the cost of the condominium unit-resulting in less affordable housing.[34] This problem raises questions about the prioritization of parking over the need for housing that is more affordable, especially in places well served by transit. Many cities in North America are reassessing their parking policy in response to this need. In Minneapolis where the parking requirement was cut by 50% to 100% for developments near transit, many developments have below-market price rent.[35] Cities like Buffalo and Hartford have eliminated parking minimums for all or certain classes of residential buildings.

Storm Water Capacity

Toronto's parking policy for high-rise residential buildings also has a significant impact on stormwater management. The City's *Tall Buildings Design Guidelines* states a preference for below-grade parking.[36] In effect, this is more than a preference and is better described as an unofficial mandate enforced through the City of Toronto's planning department.

The mandate for the construction of underground parking structures has exacerbated Toronto's stormwater problems through a somewhat complex interplay with groundwater. Supplying underground parking to serve high-rise buildings means the construction of up to six levels of underground parking, where groundwater is often encountered. The proliferation of tall buildings with hundreds of suites necessitates deep multi-level underground parking structures then increases the pressure of groundwater or hydrostatic pressure on buildings, as well as on the surrounding geology, decreasing the ground's geological capacity to hold additional water from precipitation. As a result, the City's stormwater and sewage systems are frequently over-capacity, especially in times of high rainfall, creating significant safety, health and sanitation problems from flooding and sewage overflows.

Toronto has identified the long-term policy of eliminating all groundwater discharge from buildings into the sewage system, by moving towards water-tight below grade parking structures. While this may begin to address the groundwater problem,[37] the policy to

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[33] Bond, R. 2015
[34] Crowther, H. 2016
[35] Spivak, J. 2018
[36] City of Toronto 2013
[37] Shintani, L. 2018

prohibit most above-grade parking will continue to exacerbate the overall stormwater problem, as each additional new underground parking structure increases the pressure on the groundwater table, while also further eroding housing affordability as creating water-tight underground parking structures is a very costly and complex undertaking.

In addition to reviewing the minimum parking requirements as a response to declining demand for parking, allowing above-grade parking structures will more readily address the stormwater problem by removing the physical pressure exerted on the water table from buildings sunk deep into the ground. Using street-friendly design, many cities have demonstrated that above-grade parking need not interrupt street life and vitality or diminish aesthetics and urban design.

Figure 8: Street-friendly above-grade parking

Figure 8 above shows an example of a high-rise building with street level retail, followed by above-grade parking and residential units

[38]

The Role of Governance/Policy in Parking

Parking policy is another critical factor affecting parking supply because of their endogenous relationship.[39] Not only is automobile ownership a determinant of parking supply, but

[38] Retrieved from Council on Tall Buildings and Urban Habitat (https://www.ctbuh.org/)
[39] Guo, Zhan 2013

parking supply is also a determinant of automobile ownership. Inexpensive parking supply lowers the automobile ownership cost and thereby increases the likelihood of vehicle ownership. Parking supply is in turn determined by demand models that are based on automobile ownership, as regulated through zoning policy. In addition to this, zoning policy governs density and determines transit feasibility and modal split.

Parking policy is the primary method by which parking supply is managed. Studies show that parking supply, in turn, is a determinant of automobile ownership because parking is a component of automobile ownership costs.[40] This means that in theory, parking policy can be used to control automobile ownership. Parking policy should therefore not only respond to changing automobile ownership in order to mitigate the negative externalities of parking over-supply but be used to influence automobile ownership rates according to the identified goal of reducing automobile dependency, especially in transit-oriented dense urban centres. As stated in the City of Toronto Official Plan, "the Plan provides complementary policies to make more efficient use of infrastructure and to increase opportunities for walking, cycling, and transit use and support the goal of reducing car dependency through the City." Although the Official Plan outlines these overarching policy goals, they are not well articulated or codified into by-laws and ordinances.

In the older quarters of European cities, which were built long before motorized transportation became a norm, the built form does not account for parking. Street widths are narrow to permit on-street parking. Buildings were constructed without underground parking facilities. Therefore, the inability to park vehicles in older parts of towns is correlated with lower automobile ownership.

The Progression of Toronto's Parking Policy

Historically, the goal of optimizing traffic flow through streets has been a critical determinant in the development of on-site parking policy in Toronto and other North American cities. This was the rationale behind the establishment of on-site minimum parking requirements in many North American cities.[41] The following is a discussion of Toronto's parking policy progression since pre-amalgamated Toronto. The review shows there has not been a substantial change in minimum parking requirements since then.

Toronto's current zoning by-law regulating minimum parking requirements is zoning by-law 569-2013. This by-law is a result of by-law reviews starting in 2004[42] and was made necessary by the amalgamation of Etobicoke, North York, East York, York, Scarborough and Toronto into the City of Toronto in 1998. Before this, these municipalities regulated parking under their distinct by-laws. In most of these municipalities, the by-laws were last reviewed as much

[40] Guo, Zhan 2013
[41] Shoup, Donald C 1995
[42] Haines, G. 2014

as 10 to 50 years before the reviews starting in 2004. York and East York had reviews in the 1950s and 60s, the former City of Toronto in the 1970s and North York in 1994.[43]

The following tables show the minimum parking requirements in Toronto's downtown core as established by by-law 438-86 and by-law 569-2013.

Table 6: Toronto's by-law 438-86 (former) minimum parking requirement/unit[44]

	Bachelor	1bd	2bd	3bd+	Visitor
Downtown Core	0.3	0.5	0.75	1.2	0.06

Table 7: Toronto's by-law 569-2013 (current) minimum parking requirement/unit

	Bachelor	1bd	2bd	3bd+	Visitor
Downtown (PA 1)	0.30	0.50	0.80	1.00	0.1
Centres on subways (PA 2)	0.60	0.70	0.90	1.00	0.1
Avenues on subway stations (PA 3)	0.60	0.70	0.90	1.00	0.1
Other Avenues (PA 4)	0.70	0.80	0.90	1.00	0.15
Other	0.80	0.90	1.00	1.20	0.2

As stated earlier in the report, the minimum parking requirements of by-law 569-2013 were established based on the Cansult Ltd. 2007 survey and did not differ substantially from the recommendations made, which suggested a minimum parking requirement of 65% of the average automobile ownership rate in downtown Toronto, and 95% in other parts of the City. A comparison between the minimum parking requirements for the downtown area of Toronto in by-law 438-86 with that of the same area in by-law 569-2013 (Table 8) shows that change has not been substantial.

The minimum parking requirements for downtown Toronto have mostly remained consistent since 1986. This implies that parking policy in Toronto has not been used to influence automobile ownership in the over three decades. Considering the above-discussed impacts of car-sharing and ride-hailing on automobile ownership in Toronto, another important implication of this comparison is that it might be prudent to review and revise Toronto's

[43] Engel-Yan, Joshua 2010
[44] 438-86 pg 70, 340,

minimum parking requirements in response to changes in automobile ownership and trends in mobility and new mode choices.

Table 8: Minimum parking requirements in downtown Toronto (by-law 438-86, 569-2013)

	438-86	569-2013
Bachelor	0.3	0.30
1bd	0.5	0.50
2bd	0.75	0.80
3bd	1.2	1.00
Visitor	0.06	0.1

The Future of Parking Policy in Toronto

Several planning studies for the Greater Toronto Area place a strong emphasis on reducing automobile dependence in the long run. These include *the 2041 Regional Transportation Plan* of Metrolinx, The Growth Plan for the Greater Golden Horseshoe from the Ministry of Municipal Affairs, and Toronto's Official Plan.

The 2041 Regional Transportation Plan identifies the development of an extensive network of rapid transit lines in the Greater Toronto and Hamilton Area over 20 years. The identified strategies of optimizing the transportation system and integrating transportation and land use are targeted at the reduction of automobile dependence, and will include such action points as the development of mixed-use transit-oriented communities at station areas, transit fare integration, the incorporation of first and last mile transportation options, expansion of the HOV lane network, parking management and others. Opportunities exist for adequate parking management through land use strategies that minimize automobile dependency, as well as supply-side policies such as the use of maximum parking limits.[45]

Toronto's Official Plan speaks of reducing vehicle ownership, household transportation costs and the adverse environmental effects of automobile dependence. One strategy outlined is the operation of Toronto Parking Authority public parking facilities as community transportation hubs, through the incorporation of car-sharing, taxi pick-up points, and bicycle parking.[46] The City of Toronto has also implemented amendments to the 438-86 zoning by-law, and the 569-2013 by-law which allow for minimum parking requirement reductions with the incorporation of car-share parking stalls, by a ratio of about one car-share stall to replace 3 or 4 regular parking spots, up to a maximum number of car-share spots provided.[47] Also,

[45] Metrolinx 2018
[46] City of Toronto 2010
[47] See "*Car-Sharing in Toronto*" above

the City of Toronto adopted a *Free-Floating Car-Share Pilot and Interim Policy* on April 24, 2018, which allows the parking of free-floating car-share vehicles on some streets segments where parking is otherwise restricted to residential permit parking as part of a pilot project from June 1, 2018, to November 30, 2019.[48]

In addressing the goal of reducing automobile dependence, reducing minimum parking requirements through the incorporation of car-sharing parking spots is supported by studies that show that supplying additional parking can increase car ownership.[49] The implication is that Toronto can reduce the reliance on the private automobile for mobility in areas where public transit serves as a viable mobility alternative by reducing parking supply through its current strategy of replacing regular parking spots with car-share stalls.

The strategy above hinges on the assumption that parking minimums do control the supply of parking. One study examined this assumption with mixed findings -- for certain commercial land uses, including office and retail, reducing the minimum parking requirement was a successful strategy in reducing the supply of parking.[50] This strategy, however, did not reduce parking supply for other commercial uses such as grocery stores. This indicates that for land uses where minimum parking requirements are a significant factor in supply decisions, supply is responsive to a reduction of the minimum parking requirement. The same may not be right for other land uses.

When these implications are applied to residential land uses, the research suggests that the responsiveness of parking supply at high-rise residential buildings in Toronto to minimum parking requirement reductions will depend on what the relative importance of minimum parking requirement for such land uses are when compared with other factors that affect parking supply.

One crucial factor to consider in the supply of parking for high-rise residential buildings is marketability. A study of developers in the Toronto area found that builders consider parking availability as a desirable attribute for the marketability of a condominium in a high-rise building. Developers believe that the supply of parking required for a unit to be marketable is at times above the minimum parking requirement, and at other times, below it.[51] The implication is that at certain locations, residents place a high premium on access to a parking spot. Several other studies have also observed a strong attachment to parking.[52]

In summary, the review of the historical progression of parking policy in Toronto has shown that minimum parking requirements have not changed substantially for decades, which contradicts many overarching policy frameworks aimed at reducing automobile dependence. This, together with the impact of ride-hailing, car-sharing and the potential of autonomous

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[48] Toronto City Council 2017
[49] Guo, Z. 2013
[50] Engel-Yan, J. 2007
[51] Haines,G. 2014
[52] Shoup, Donald 2017; Weiner, A. 2013

vehicles point to a possibility of over-supply of parking at high-rise residential buildings in downtown Toronto that may not be in line with Toronto's Official Plan. This is especially true for those high-rise residential buildings that are well-served by higher order transit.

Given the expected changes in automobile ownership brought about by the changes in mobility-related technologies, it is quite likely that if the minimum parking standards are not revised downwards, new residential high-rise buildings will be left with an oversupply of parking, which if provided below grade will result in redundant space that will not be able to be repurposed in the future. This underscores the importance of reviewing Toronto's minimum parking requirements.

The next section discusses strategies for addressing the parking over-supply problem now and in the future.

Innovative Solutions to the Parking Problem

This report has so far examined the question of parking regulations for high-rise residential buildings in Toronto with a specific focus on the downtown core. The reduction of minimum parking requirements can potentially reduce parking supply. This approach, however, may not fully address the problem of oversupply now, or in the future, as mobility patterns could cause a reduction in automobile ownership that may render some of the dedicated parking stock redundant. This section of the report examines other strategies that can be implemented to address this problem. The strategies examined are broadly of two kinds -- innovative parking regulation, and innovative parking infrastructure design.

Innovative Parking Regulation

Parking regulations within a jurisdiction are generally based on traditional minimum requirements, area-specific requirements, or flexible requirements.[53] Each approach offers a unique set of advantages and disadvantages that must be considered before adoption. Jurisdictions must choose the approach or combination of approaches that best suit their local transportation, business, and political contexts.

Traditional Minimum Parking Requirements

Traditional minimum parking requirements applied throughout a jurisdiction focus solely on land use type and building size to the exclusion of other factors that influence parking demand such as access to transit, geography, demographics, availability of public lots, and the popularity of specific businesses. This approach provides minimum parking requirements for specific land uses (restaurants, auto mechanic shops). Minimum parking requirements for given land uses are often determined by collecting data on peak daily parking demand and setting a parking ratio (e.g. the number of parking spaces per 100 square meters of gross floor area) based on the 85th percentile of demand.[54]

Traditional minimum parking requirements offer several benefits. They can be easily determined based on readily available gross floor area data, are relatively simple to enforce as they are consistent throughout a jurisdiction and integrate well with traditional zoning codes. However, traditional minimum parking requirements are often insensitive to local policy objectives, as they cannot be altered to reflect the needs of transit-oriented developments or secondary planning districts and are inflexible to the land use considerations of specific sites. Minimum parking requirements can also increase development costs which may impact housing supply and affordability while an oversupply of free or below market value parking spaces can increase congestion as motorists are more inclined to drive to areas where such parking is available.[55]

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[53] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.377.5225&rep=rep1&type=pdf
[54] The Dimensions of Parking, 4th Edition
[55] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.377.5225&rep=rep1&type=pdf

Area-Specific Parking Requirements

Area-specific parking requirements offer a zone-based approach which addresses the parking needs for different areas within a jurisdiction. The most common application occurs when specifying parking requirements in downtowns or central business districts. As with traditional minimum parking requirements, area-specific parking requirements for different land uses can be determined by setting a parking ratio based on the gross floor area.

Area-specific parking requirements can address local transportation and land use conditions and policy objectives more readily than traditional minimum parking requirements. This approach can isolate areas with lower parking demand and greater access to higher order transit, as well as areas with lower density development and higher automobile dependency and adjust parking requirements accordingly. Sensitivity to local context is often determined by the number of parking zones within a jurisdiction. If a suitable number of parking zones are chosen in accordance with existing planning areas, the implementation and enforcement of parking standards require little institutional change.[56]

Flexible Parking Requirements

Flexible parking requirements provide reductions to traditional parking requirements and often respond more readily to parking demand based on existing conditions at or around a site such as geography, demographics, and mix of uses.

Flexible approaches include shared parking spaces that serve multiple users or destinations and fees instead of parking that allow developers to pay into a municipal parking fund instead of providing on-site parking.[57,58] Minimum or maximum parking requirements can also be adjusted based on site conditions such as the number of affordable housing units, transit accessibility, and availability of nearby offsite parking. These initiatives constitute a range of parking management strategies aimed at responding to demand peaks and reducing the amount of parking needed by using existing resources more efficiently. Effective use of these strategies can also reduce congestion, improve traffic conditions, and encourage more compact land use development.[59]

Flexible parking requirements can provide context-specific solutions that adjust to parking demand more effectively than district or city-wide parking standards. However, the trade-off for this increased sensitivity is added complexity. Flexible parking requirements are more challenging to enforce and less predictable for developers and city officials. As a result, they may not completely align with planning and policy objectives. Additionally, certain factors that influence site-specific parking requirements, such as the availability of transit or nearby

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[56] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.377.5225&rep=rep1&type=pdf
[57] Flexible Parking Requirements – Smith, T.
[58] https://www.mapc.org/resource-library/fees-in-lieu-of-parking-spaces/
[59] http://www.vtpi.org/PMBP_ITE_SEPT2008.pdf

offsite parking, can change throughout a development cycle resulting in an over- or undersupply of parking.[60]

Innovative Parking Infrastructure

The projected decline in parking requirements due to automated vehicle technology and increased transit and ridesharing patronage has prompted municipalities to explore options for adaptive reuse of parking structures. Surface parking lots can be easily converted to a different use. However, converting parking garages or building parking structures with future conversion in mind requires innovative design strategies. Even though converting an underground parking structure beneath a residential building to another use could be technically possible, a conversion of this nature might be futile if market demand for underground floor area does not warrant the effort. It is for this reason that above-grade parking structures incorporated into a residential building can be advantageous as potential groundwater issues are avoided, while also offering future marketable use alternatives.

Design Considerations

Parking structure floors are typically sloped slightly to allow rain and snow to drain. Garages that can be converted to residential or commercial uses in the future will, in many cases, be constructed without sloping floors while existing garages will require levelling of sloped floors. Ramps present another difficulty for adaptive reuse. Convertible garage designs can eschew ramps altogether in favour of other options such as car elevators or install ramps which can be removed later. An example of this can be seen in the planned 9th Avenue SE Parkade & Innovation Centre in Calgary where the parking structure will be built with gentle slopes that can be topped to make them level, instead of ramps.[61]

Parking garages typically have the floor to ceiling heights of 10 feet or less. In some instances, convertible parking garages will require floor to ceiling heights between 10 and 15 feet to accommodate future residential or commercial uses. This potential increased floor to ceiling height may also necessitate the construction of speed ramps which decreases the number of parking spaces available per floor. As a result, more floors will have to be constructed to maintain the same number of parking spaces. These modifications, when taken together, could result in a more expensive foundation system.[62]

Residential and commercial uses have different structural loading and vibration requirements than parking garages.[63] Convertible parking structures must, therefore, be constructed with the requisite structural integrity and design elements to accommodate potential future uses. For example, concrete pillars found in many parking structures must be placed in areas that

[60] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.377.5225&rep=rep1&type=pdf
[61] Moore, O. 2018
[62] Future-Proofing Parking – Blumgart, J.
[63] https://www.floridatrend.com/article/26279/adaptive-reuse-of-parking-structures

do not interfere with future uses while modifications to lighting and heating systems must also be addressed.

The construction and placement of elevators and stairs in convertible parking garages may also require new designs. Most residential and commercial buildings have elevators located in the centre of the building and stairs located in the corners. However, most parking garages have elevators and stairs located in the corners and sides of the building which is less desirable for future residential and commercial uses from a design and efficiency standpoint.[64] Locating elevators and stairs in the centre of convertible parking garages may require more square footage than placing them at the edges of the building thus decreasing the number of parking spaces available per floor. Also, centrally located elevators and stairs could impede optimal parking stall spacing and traffic flow.

Adaptive Reuse and Design of Parking Structures – Case Studies

Global architecture firm Gensler[65] has been developing new designs that envision how parking garages can be converted into residential, commercial, or public spaces. Gensler designed a hypothetical LA building known as 'The MOD' which transitions from a parking structure to a cultural centre. Floor to ceiling heights are increased, and floors between ramps are levelled to accommodate future uses. The design also includes modular sections and knockout panels so that walls and ceilings can be removed to improve natural light and air circulation.[66]

Figure 9: The MOD concept in LA

Source: https://www.curbed.com/2017/4/26/15421594/parking-garages-driverless-cars-gensler

[64] https://www.floridatrend.com/article/26279/adaptive-reuse-of-parking-structures
[65] https://www.gensler.com/
[66] https://www.curbed.com/2017/4/26/15421594/parking-garages-driverless-cars-gensler

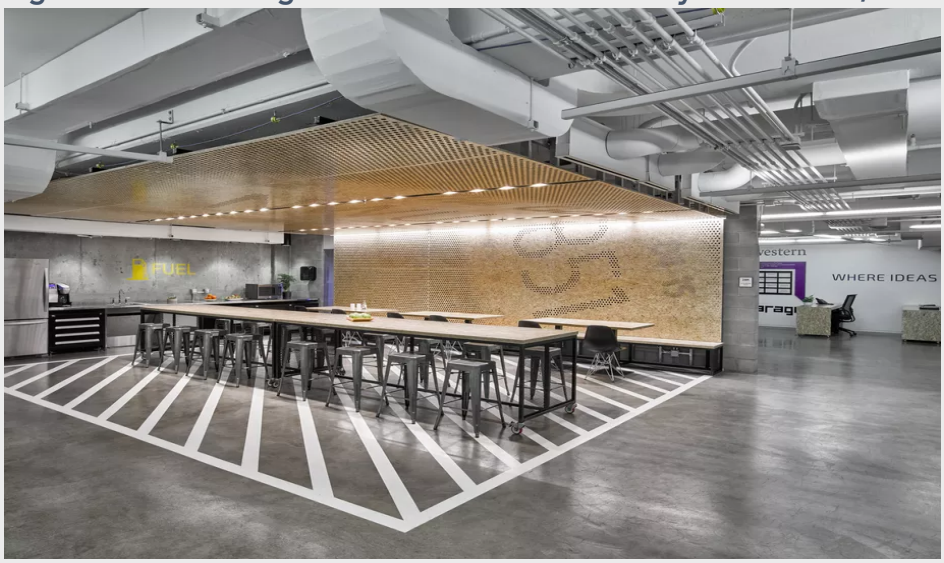
The 84.51 Centre in Cincinnati, Ohio is a mixed-use development which includes street-level retail and the 280,000 square foot headquarters of consumer analytics company 84.51.[67] Three floors of parking are situated between the ground floor and the office floors and are designed to be converted into office space as needed. The façade of the parking floors matches the rest of the building and ventilation screens can be replaced with windows once conversion takes place.[68]

Figure 10: 84.51 Centre (Cincinnati, Ohio)

Source: https://www.curbed.com/2017/4/26/15421594/parking-garages-driverless-cars-gensler

The Garage at Northwestern University in Evanston, Illinois is a 12,000 square foot entrepreneurial innovation centre. Classroom spaces, shared areas, and drop-in stations are all located within a retrofitted parking garage whose design elements include stripes that once delineated parking spaces.[69]

Figure 11: The Garage at Northwestern University in Evanston, Illinois



Source: https://www.curbed.com/2017/4/26/15421594/parking-garages-driverless-cars-gensler

The Summit is a 426,000 square foot hotel in Cincinnati, Ohio that was once a parking garage. The $80 million

[67] https://www.gensler.com/projects/84-51-centre-1
[68] https://www.curbed.com/2017/4/26/15421594/parking-garages-driverless-cars-gensler
[69] https://www.gensler.com/projects/northwestern-university-the-garage

hospitality venue feature 239 rooms, an art gallery, rooftop terrace, ballroom, and 19 meeting spaces. A complete teardown of the parking structure was considered before months of value engineering determined that adaptive reuse of the structure was financially viable. The parking facility had an 85,000 square foot floorplate and had already been stripped of its cladding. The Summit's nine storey atrium allowed structural loads to be redistributed maximizing the building's height.[70]

Figure 12: The Summit (Cincinnati, Ohio)

Source: https://www.bdcnetwork.com/work-park-live-inside-cincinnati%E2%80%99s-parking-garage-turned-

Denizen is a 275-unit mixed-use community completed as part of Denver Regional Transportation District's Transit-Oriented Development Pilot Program. The complex is located 20 feet from a light rail station platform includes restaurants, retail, car- and bike-sharing programs. Thirty of Denizen's 275 parking spots can be converted into 7,000 square feet of future street-level retail space. The current street level parking garage is exposed rather than concealed to facilitate the transition.[71,72]

Figure 13: Denizen in Denver

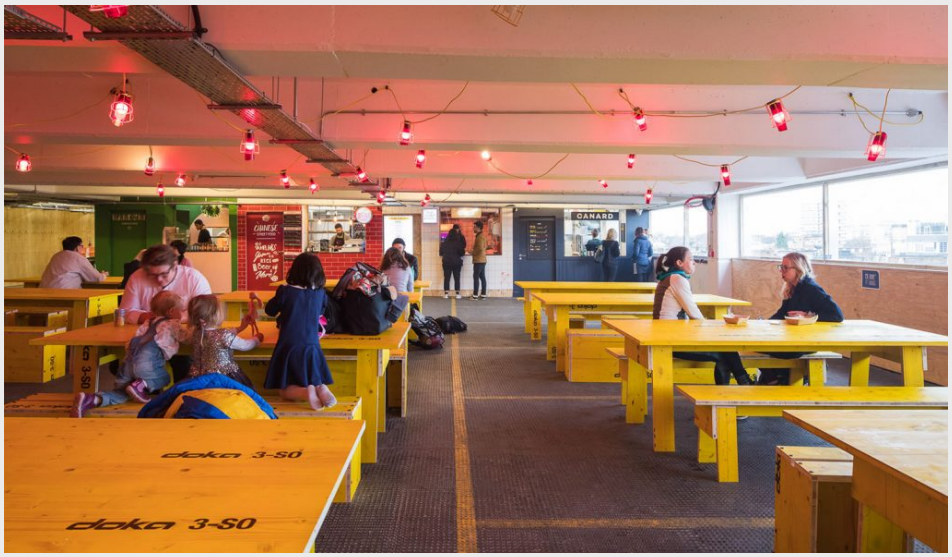
Source: https://www.bisnow.com/denver/news/multifamily/denver-is-future-proofing-its-parking-garages-80018

Peckham Levels is a community hub and art space located in a refurbished parking garage in London, England. The goal of this grassroots project is to provide an affordable and

[70] https://www.bdcnetwork.com/work-park-live-inside-cincinnati%E2%80%99s-parking-garage-turned-lifestyle-hotel
[71] https://www.bisnow.com/denver/news/multifamily/denver-is-future-proofing-its-parking-garages-80018
[72] https://www.denverpost.com/2016/10/15/denver-developers-future-parking-self-driving-cars/

inspiring space for independent businesses, artists, and local entrepreneurs. The seven-storey structure is being temporarily leased until 2023 and includes 50 studio spaces, 10 of which are used as incubator spaces with subsidized rent. Peckham Levels also features event spaces, restaurants, children's play areas, a 3D printing lab, and a yoga studio.[73,74]

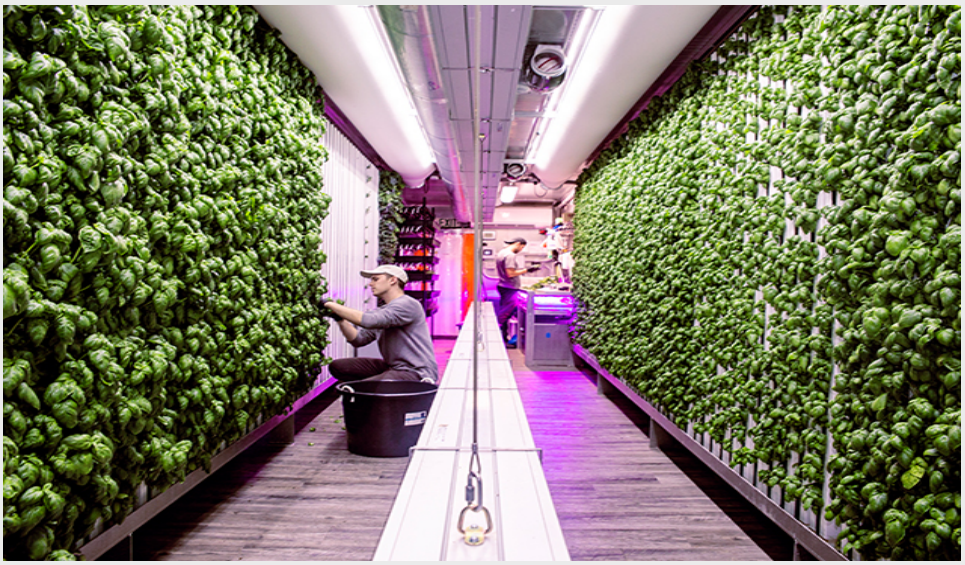
Figure 14: Peckham Levels (London, England)



Source: https://www.ibigroup.com/ibi-ideas/shifting-gears-exploring-the-future-of-parking-garages/

Square Roots is an organization that has developed an urban agriculture residency program that teaches young people about sustainable farming practices. The seed-to-sales urban farm uses modular and water efficient hydroponic growing systems and operates out of several shipping containers located on the roof of a Brooklyn parking garage. Square Roots grows, harvests, packages, and delivers herbs to retail stores across New York City providing strong local connections between customers, farmers, and their food.[75,76]

Figure 15: Square Roots in Brooklyn, New York



Source: https://squarerootsgrow.com/about_us/

[73] https://www.peckhamlevels.org/about
[74] https://www.ibigroup.com/ibi-ideas/shifting-gears-exploring-the-future-of-parking-garages/
[75] https://squarerootsgrow.com/about_us/
[76] https://www.ibigroup.com/ibi-ideas/shifting-gears-exploring-the-future-of-parking-garages/

Conclusions

Minimum parking requirements have long been a staple of urban planning regulations. Based on some formulation, most municipal planning authorities require developers of commercial and residential buildings to provide a minimum number of parking spaces. These regulations, unfortunately, have been driven by postwar auto-centric engineering models. Addressing increased vehicle traffic was typically dealt with by building wider roads in the suburbs to accommodate a higher influx of drivers to the inner core, where a lack of off-street parking resulted in the provision of more below grade and above ground parking structures.

Over the past seven decades, the built form in Toronto has evolved significantly. From the postwar cookie-cutter suburbs to the high-rise towers in downtown Toronto, initially for office purposes but eventually for residential and mixed uses. Further, changes in construction technology, demographics, and travel behaviour have altered this region's urban form and built environment.

Recent changes in transportation technology and services, characterized by ride-hailing and automobile sharing, and the emerging technologies dominated by autonomous vehicles suggest that automobile ownership is likely to experience modest declines in the future. Furthermore, autonomous vehicles can displace parking requirements in the urban core, where the land is expensive, to the periphery where land is cheaper. In addition, AVs will require much less space to park the same quantity of vehicles.

Overall, these trends necessitate that minimum parking standards be revised across Toronto, but especially in the urban core, where automobile ownership is likely to be lower in the future. A failure to revise parking standards could result in surplus underground parking, which will, given the current design and construction practices, make these underground spaces difficult to repurpose in the future.

At the same time, building underground parking garages is an expensive endeavour that drives up the cost of construction. Thus, minimum parking requirements have a direct and negative impact on the provision of housing. This impacts the City's ability to meet its objectives of delivering a range of housing options.

The evidence presented in this report suggests that Toronto's minimum parking standards, which have not been reviewed meaningfully over the past three decades, be revised to bring them in line with the expected changes in automobile ownership and travel behaviour. Also, innovative above-grade parking options enable building owners to repurpose parking spaces for more efficient uses in the future, if and when parking space becomes redundant. Underground parking does not readily permit the repurposing of parking to marketable space in the future. Hence, there is a need to revise parking standards to allow for above-grade parking in high-rise buildings.

Works Cited

Altus Group. (2014). *Construction cost guide*

Anowar, S., Eluru, N., & Miranda-Moreno, L. F. (2014). Alternative modeling approaches used for examining automobile ownership: A comprehensive review. *Transport Reviews, 34*(4), 441-473.

Blumenberg, E., Taylor, B. D., Smart, M., Ralph, K., Wander, M., & Brumbagh, S. (2012). What's youth got to do with it? exploring the travel behavior of teens and young adults.

Brail, S. (2018). From renegade to regulated: The digital platform economy, ride-hailing and the case of Toronto. *Canadian Journal of Urban Research, 27*(2), 51-63.

Bond, R., Ellis, K. (2015). Will that be a parking space for the new condo, or something more useful? Retrieved 04/05, 2019, from https://canadianparking.ca/will-that-be-a-parking-space-for-the-new-condo-or-something-more-useful/

Burda, C. (2012). RBC-Pembina home location study: Understanding where Greater Toronto Area residents prefer to live. *Report by Pembina Institute and the Royal Bank of Canada.*

Burda, C., & Haines, G. (2012). Drivers' choice.

Cansult Ltd. (2007). *Parking standards review – phase two apartment building / multi-block development component, new zoning by-law project.* City of Toronto.

City of Toronto. (2010). *Official Plan*

Clayton, F. (2018). *Car-Owning Households up by 355,000 in the GTHA, 88,000 in the City of Toronto, and 26,000 in the Toronto Core since 2006*. Retrieved March 6, 2019, from https://www.ryerson.ca/cur/Blog/blogentry28/.

Clewlow, R. R., Mishra, G. S. (2017). Disruptive transportation: The adoption, utilization, and impacts of ride-hailing in the united states. *University of California, Davis, Institute of Transportation Studies, Davis, CA, Research Report UCD-ITS-RR-17-07.*

Cook, T. (2015). *Ground transportation review: Taxis, limos and Uber.* City of Toronto.

Crowther, H. (2016), Above-grade parking hobbles Edmonton's tallest high-rise. The Globe and Mail.

Data Management Group. (2016). *Transportation tomorrow survey.*

Davis, B., Dutzik, T., & Baxandall, P. (2012). Transportation and the new generation: Why young people are driving less and what it means for transportation policy.

Deka, D. (2018). Are millennials moving to more urbanized and transit-oriented counties? *Journal of Transport and Land use, 11*(1).

Editorial Desk AAU. (2019). Melbourne council moves to end car parking requirements for new developments. 2019, from https://architectureau.com/articles/melbourne-council-to-axe-minimum-car-park-requirements-under-new-transport-strategy/

Engel-Yan, J., Hollingworth, B., & Anderson, S. (2007). Will reducing parking standards lead to reductions in parking supply? Results of extensive commercial parking survey in Toronto, Canada. *Transportation Research Record: Journal of the Transportation Research Board,* (2010), 102-110.

Engel-Yan, J., & Passmore, D. (2010). Assessing alternative approaches to setting parking requirements. *Institute of Transportation Engineers. ITE Journal, 80*(12), 30.

Engel-Yan, J., & Passmore, D. (2013). Carsharing and car ownership at the building scale: Examining the potential for flexible parking requirements. *Journal of the American Planning Association, 79*(1), 82-91.

Flamm, M., & Geiger, D. (2018). PARKING IN REVERSE; Uber and Lyft crushed taxis. is the garage business next? *Crain's New York Business, 34*(8), 14.

Guerra, E. (2016). Planning for cars that drive themselves: Metropolitan planning organizations, regional transportation plans, and autonomous vehicles. *Journal of Planning Education and Research, 36*(2), 210-224.

Guo, Z. (2013). Does residential parking supply affect household car ownership? The case of New York City. *Journal of Transport Geography, 26*, 18-28.

Habib, K. N. (2014). Household-level commuting mode choices, car allocation and car ownership level choices of two-worker households: The case of the City of Toronto. *Transportation, 41*(3), 651-672.

Haines, G. (2014). Assessing Toronto's minimums parking requirements for condominiums.

Hampshire, R. C., Simek, C., Fabusuyi, T., Di, X., & Chen, X. (2018). Measuring the impact of an unanticipated suspension of ride-sourcing in Austin, Texas. *Transportation Research Board 97th Annual Meeting* pp. 18.

Heath, T. (2001). Adaptive re-use of offices for residential use: The experiences of London and Toronto. *Cities, 18*(3), 173-184.

Henao, A., & Marshall, W. E. (2018). The impact of ride-hailing on vehicle miles traveled. *Transportation*, 1-22.

Hess, D. B. (2001). Effect of free parking on commuter mode choice: Evidence from travel diary data. *Transportation Research Record, 1753*(1), 35-42.
Hess, P., & Farrow, J. (2010). Walkability in Toronto's high-rise neighbourhoods: Final report. *University of Toronto and Jane's Walk.*
Hill, K. (2014). A financial model comparing car ownership with UberX (Los Angeles).
Horton, T. (2014). Parking break. Master of Urban Planning, McGill University.
IBI Group. (2009). Parking standards review: Examination of potential options and impacts of car share programs on parking standards, final report.
Jia, W., & Wachs, M. (1999). Parking requirements and housing affordability: Case study of San Francisco. *Transportation Research Record, 1685*(1), 156-160.
Lavieri, P. S. (2018). *Is the Future of Urban Mobility Shared? Modeling Ride-Hailing Adoption and Preferences for Ownership and Sharing of Autonomous Vehicles,*
Legacy, C., Ashmore, D., Scheurer, J., Stone, J., & Curtis, C. (2019). Planning the driverless city. *Transport Reviews, 39*(1), 84-102.
Litman, T. (2018). *Parking management best practices* Routledge.
Manville, M., & Shoup, D. C. (2010). Parking requirements as a barrier to housing development: Regulation and reform in Los Angeles.
Marr, G. (2015). Buying a condo? maybe you should get the parking spot too. *Financial Post.*
Metrolinx. (2008). *THE BIG MOVE: Transforming transportation in the greater Toronto and Hamilton area*
Metrolinx. (2018). 2041 Regional Transportation Plan: For the greater Toronto and Hamilton area Metrolinx.
Ministry of Infrastructure. (2013). *The growth plan for the Great Golden Horseshoe*
Moore, O. (2016). UberX will be allowed to operate legally in Toronto, city council decides. *The Globe and Mail.*
Moore, O. (2018), A new lot in life: Cities transform dying parking garages into living neighbourhoods. *The Globe and Mail*. Retrieved from https://www.theglobeandmail.com/canada/toronto/article-a-new-lot-in-life-cities-transform-dying-parking-garages-into-living/
Nourinejad, M., Bahrami, S., & Roorda, M. J. (2018). Designing parking facilities for autonomous vehicles. *Transportation Research Part B: Methodological, 109*, 110-127.
Rayle, L., Dai, D., Chan, N., Cervero, R., & Shaheen, S. (2016). Just a better taxi? A survey-based comparison of taxis, transit, and ride-sourcing services in San Francisco. *Transport Policy, 45*, 168-178.
Shintani, L. (2018). Groundwater review process and proposed groundwater & construction dewatering policy. Toronto Water.
Shontell, A. (2015). Uber CEO explains his company's highly ambitious goal to end car ownership in the world. *Business Insider.*
Shoup, D. (2017). *The high cost of free parking. Updated edition* Routledge.
Shoup, D. C. (1995). An opportunity to reduce minimum parking requirements. *Journal of the American Planning Association, 61*(1), 14-28.
Shoup, D. C. (1999). The trouble with minimum parking requirements. *Transportation Research Part A: Policy and Practice, 33*(7-8), 549-574.
Smith, W. S. (1984). Mass transport for high-rise high-density living. *Journal of Transportation Engineering, 110*(6), 521-535.
Statistics Canada. (2017). Journey to work: Key results from the 2016 census. Retrieved 04/05, 2019, from https://www150.statcan.gc.ca/n1/daily-quotidien/171129/dq171129c-eng.htm
Stubbs, M. (2002). Car parking and residential development: Sustainability, design and planning policy, and public perceptions of parking provision. *Journal of Urban Design, 7*(2), 213-237.
Thigpen, C. G. (2018). Giving parking the time of day: A case study of a novel parking occupancy measure and an evaluation of infill development and carsharing as solutions to parking oversupply. *Research in Transportation Business & Management,*
City of Toronto. (1986). By-Law no. 438-86.
Toronto City Council. (2015). By-law no. 1364-2015.
Toronto City Council. (2017). By-Law 265-2017 (OMB).
Toronto City Council. (2017). By-Law 548-2017 (OMB).
Toronto City Council. (2017). *Free-floating car-share pilot and interim policy* No. PW23.8)
Vuchic, V. (1999). *Transportation for livable cities* Routledge.
Weiner, A. (2013), Tregoning: Parking minimum elimination was "Really wigging people out." *Washington City Paper.*

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