International Experience and Policy Trends in Urban (Including Dynamic) Road Pricing

Variable Road Pricing Study - Tauranga

Waka Kotahi

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CDM Smith

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1.1 Introduction

The purpose of this paper is to provide a high-level summary of international experience and lessons learned in implementing urban road pricing schemes around the world, including dynamic road pricing. This paper takes into account the context of the scale, geography, urban form and transport mode use patterns of Tauranga City in reviewing the experiences of cities across the world.

The paper is structured as follows:

- Definitions of urban road pricing, dynamic road pricing and types of urban road pricing scheme concepts;
- Identification of relevant urban road pricing systems based on functionality, rationale and scale, taking into account the conditions of Tauranga
- Summary of the characteristics of cities with urban road pricing systems, noting those with smaller populations and higher mode share by car;
- How policy objectives for urban road pricing schemes affect pricing strategies;
- Implementation considerations;
- Impacts of urban road pricing schemes;
- Modelling of operational urban road pricing schemes;
- Summary of current trends of urban congestion pricing systems, and the latest developments of policy and studies (noting specifically Singapore and Brussels, and recent studies in Australia);
- Summary of key elements in development of options for The Congestion Question and for Let's Get Wellington Moving;
- Policy issues: revenue management and system governance; and
- Key conclusions.

1.2 Definitions

Urban Road Pricing

The term *urban road pricing* is used in this paper to describe any type of pricing of existing roads that only operates during specific times of day (and days of the week). It is distinguished from tolling (as is applied in Tauranga) in the following ways:

- Tolls are used *exclusively* to recover capital (and operating) costs of the tolled infrastructure;
- Tolls operate 24 hours a day, seven days a week to maximise net revenues (and because all vehicles using the tolled road are expected to contribute towards the costs of that infrastructure), rather than seek to change behaviour;
- Tolls *may* be removed after the capital costs of the tolled road have been fully recovered, so that the ongoing maintenance costs are recovered from general highway funding (through the National Land Transport Programme).[1]

Urban road pricing may be applied to a single point on a road network, or onto an entire network of roads, with its purpose being primarily to *change road user behaviour* and raise revenue, which may or may not be applied to the network being priced. Although the primary objective of an urban road pricing scheme may be either behaviour change or revenue generation, any urban road pricing scheme will cause behaviour change (because it increases the price of travel on that road at specific times for specific types of vehicles) and will generate net revenues (as it is fundamentally a tool of revenue collection).

Urban road pricing is not permitted in New Zealand under existing legislation, which is specifically confined to permitting tolling on new road infrastructure for the purposes of recovering the costs of planning, designing, supervising, constructing, maintaining and operating that infrastructure.

Urban road pricing does not include regulatory measures, such as low/ultra-low emission zones (which apply charges or fines for vehicles that don't meet specified emission standards) or time/location-based restrictions on vehicle access. Generally such measures are not introduced to raise revenue, nor to reduce congestion, but rather to lower noxious air pollution and improve local amenity by reducing traffic volumes in sensitive locations.[2]

Managed lanes

Managed lanes is a term that encompasses any road lanes that have controls on access limiting them to a subset of vehicles which may be based on either the vehicle characteristics (e.g., bus lanes), vehicle occupancy (e.g., transit or High Occupancy lanes) or price (tolled or High Occupancy Toll (HOT) lanes). These controls only apply to selected (not all) lanes within a corridor, with general (unmanaged) lanes continuing to exist with no such controls. If all

[1] The Land Transport Management Act 2003 (ss. 46-55) enables tolling for new road capacity only and requires that there be a feasible untolled alternative route.
[2] Low-emission zones are widespread in Germany and increasingly being introduced in UK cities. Regulatory access schemes are widely used in Italian cities to limit vehicle access to residents' vehicles, service vehicles and local deliveries.

lanes are managed by regulation, the road is only for a specific class of users (e.g., a busway) or if by price, the entire road is effectively subject to a toll or an urban road pricing scheme.

Types of urban road pricing schemes

There are five general types of urban road pricing scheme

Cordon: A cordon places a virtual line across a series of roads, so that all trips in either one or both directions across that line are subject to a fee during specific times of day. This type of scheme is seen in Singapore, Stockholm, Gothenburg, Abu Dhabi, Milan, Oslo, Valetta, Tehran and Durham. A cordon is a recommended option for the Auckland city centre from The Congestion Question study.

Cordons can be applied in a single direction of travel, or both, and may be applied for peak periods only, or all day, with charges varying on the time of day. All cordons apply similar charges for entering the cordon regardless of location, but multiple cordons may be applied concentrically (e.g., Oslo) with different charges.

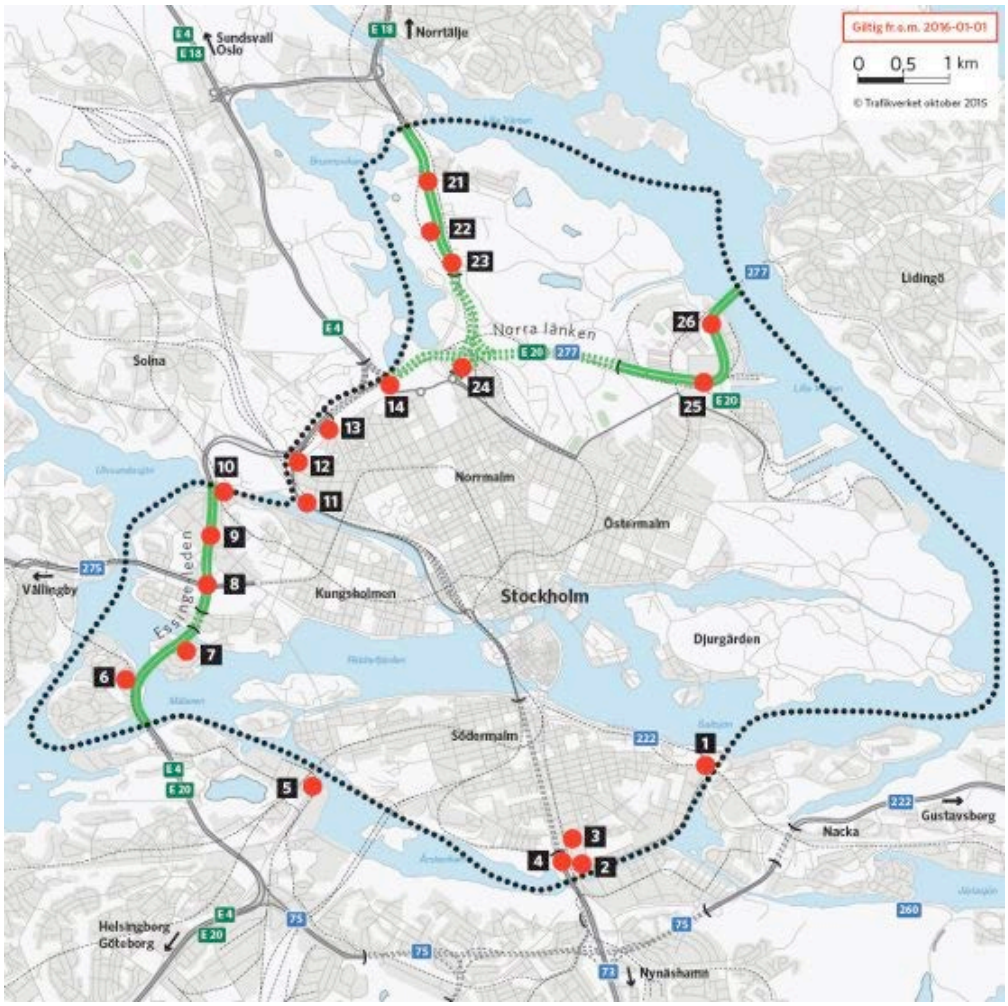

Figure 1 Stockholm congestion tax cordon with charging points

Figure 2 Oslo's triple cordon ("toll ring")

Area: An area charge is similar to a cordon. However, in addition to trips that cross the cordon, an area charge also charges trips that commence (and may terminate) within the boundaries of the cordon. Unlike cordons, which can distinguish between individual trips crossing specific points (using fixed infrastructure at the cordon points), area charges are applied by having a network of points for charging to attempt to capture all vehicle movements within the area. As a result, area charges apply a single fee for all trips regardless of direction of travel, within a charging period. The only operational area charge scheme is London.

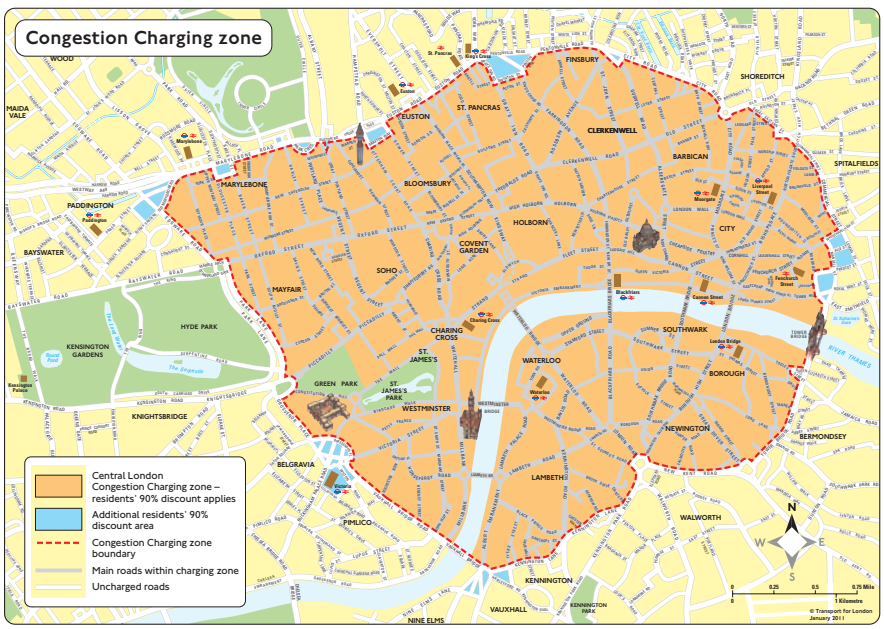

Figure 3 London Area Charge

Corridor: Corridor charges are like tolls in that they may be applied to a single road, or all roads in a corridor, at one or multiple points, in one or both directions of travel. Charges can vary at each point, in either direction. Multiple corridors may have charges applied that vary by location and time of day. Singapore, Dubai and Seoul all have corridor charging schemes of various scales of operation.

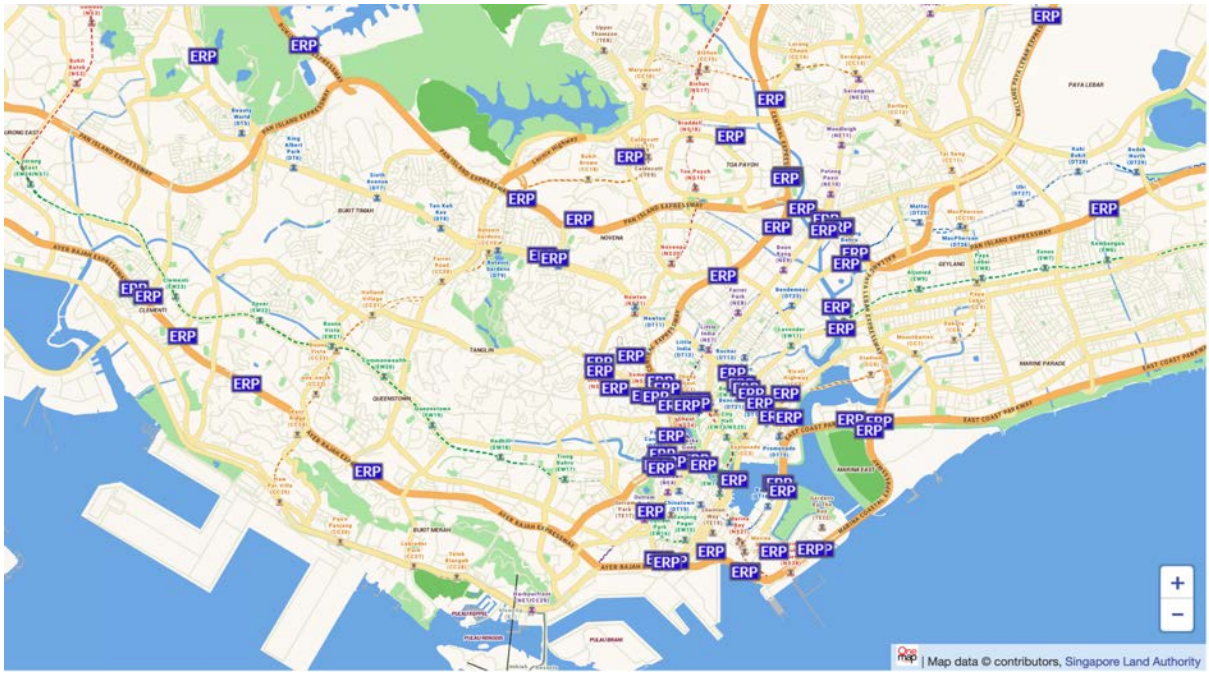

Figure 4 Singapore Corridor (and cordon) charge points

Network: Network pricing applies charges to use most or all roads within a defined location, by metering their road use by distance. Such charges vary by time of day and may also vary by location. No current urban road pricing schemes are network charges, but the Brussels-Capital Region Government in Belgium is planning to pilot network charges across the city/region, which vary by time of day and type of vehicle. The programme, called Smartmove, intends to trial replacing annual vehicle registration fees (which average around €1,000 a year) with a distance-based network charge, with higher charges during peak periods.[3] The technology proposed is to use mobile phones, supported by an extensive network of automatic number plate recognition cameras. There have been various proposals for network based urban road pricing schemes advanced in the UK, Netherlands and Finland, none of which have progressed, due to public opposition. New Zealand's Road User Charge system is a basic version of network road pricing, albeit applying to all public roads, with no differentiation by time of day, with variations by vehicle type.

Priced, managed lanes: There are two main types of priced managed lanes (including either newly built capacity or existing capacity converted to a priced managed lane:

[3] https://smartmove.brussels/en

- High Occupancy Toll lanes (HOT lanes). Lanes that allow high-occupancy vehicles (HOVs: those with two or three or more occupants) to travel untolled but permitting other vehicles to use them for a toll.

- Toll lanes. Lanes that only permit access for a toll.

HOT and toll lanes may have set prices for specific times in specific directions or may have prices that change in near real time (dynamic pricing) to manage demand to sustain a declared level of service. Pricing is applied to new capacity to ensure that demand is managed so that the improved level of service from the new capacity is sustained, and that those benefiting directly from the new capacity (although not those benefiting from the shift from the old capacity to the new capacity) pay for it. There are around 53 HOT or toll lanes in the United States and one in Israel. Most such HOT or toll lanes are formerly HOV lanes that have been converted to HOT lanes in order to increase their utilisation. A small proportion include brand new capacity or links that connect HOT or toll lanes so that they form a "network" of priced managed lanes.[4] However, rarely do new toll or HOT lanes raise enough revenue from tolls to pay for their construction.

A key feature of priced, managed lanes are that they are the only example of *dynamic* rather than *variable* road pricing. Priced, managed lanes are always placed on limited access highways (so access to and from the priced lanes can be controlled and enforced), with at least two untolled lanes in each direction, and sufficient distances between entry and exit points to avoid the need for vehicles to weave from the tolled lanes across untolled traffic. Such conditions do not exist on any highways existing or planned for Tauranga in the foreseeable future.

[4] See LA Metro Express Lanes https://rafu.com/wp-content/uploads/2012/07/ExpressLanes_Map_Toll_Entry.pdf

1.3 Variable road pricing and dynamic road pricing

For the purposes of this paper, it is important to clearly distinguish between variable road pricing and dynamic road pricing.

Almost all urban road pricing systems have *variable* pricing.[5] Variable pricing, is road pricing that varies by time of day and location, beyond the general operating hours and location of the road pricing scheme. This is seen most obviously in Singapore's Electronic Road Pricing (ERP), where each charging point has different prices across a day. As can be seen in Figure 5, this means prices are set in blocks as short as five minutes, so that drivers do not drive erratically to avoid large increases in charges. Each charging point in Singapore has a different price schedule for different times of day and direction of travel.

Variable pricing is regularly reviewed and changed according to network performance measures. In Singapore pricing is changed at four-monthly intervals following a review of speeds at each charging point, with prices being increased or reduced (or applied for longer or shorter periods) according to that review. Singapore applies a metric of performance of speeds of 45-65 km/h for expressways and 20-30km/h for local roads (with higher speeds resulting in lower charges and lower speeds higher charges). This has proven to be highly successful in managing congestion and (with the exception of occasional incidents, such as accidents or vehicle breakdowns) maintaining acceptable levels of service on roads subject to pricing.

PIE into CTE (42)

Cars/Light Goods/Taxis (Weekdays)

07:00 - 07:30	$0.00
07:30 - 07:35	$0.50
07:35 - 08:00	$1.00
08:00 - 08:05	$1.50
08:05 - 08:30	$2.00
08:30 - 08:35	$2.50
08:35 - 09:55	$3.00
09:55 - 10:00	$1.50
10:00 - 22:30	$0.00

Figure 5 Singapore ERP variable pricing for a single corridor charging point

Road pricing systems in Sweden, Norway and Malta also have prices that vary by time of day (their road pricing system operating hours. In all of these cases, the relevant cities have found that variable prices deliver significant positive results in reducing peak traffic volumes and congestion. In Stockholm, it is notable that around half of trips that changed behaviour at the

[5] Some have fixed pricing, with a single rate during charged periods. London, Abu Dhabi and Milan are examples of those with fixed pricing.

peaks changed mode of travel, whereas others either changed time of travel or did not travel. By contrast London does not have variable pricing, as it is the same price to drive within the central London congestion charge zone at any time during its operating hours. The price is either on or off.

Dynamic pricing is a form of variable pricing that is not fixed in advance of the day of travel, but pricing that varies according to real-time demand on a specific road or lane (typically within a range of prices). Pricing may apply at all times (24/7) or just at specific operating times at a minimum rate (e.g., a base rate of say 70c to recover transaction costs), or only during specific times, with rates varying during those times. In some cases pricing may only operate in one direction of travel (as in reversible priced managed lanes)

Dynamic pricing has only been implemented on priced managed lanes, it has not been implemented nor is planned to be implemented in any cities for any other type of urban road pricing scheme.

The advantage of dynamic pricing over standard variable pricing is that it can be used to sustain a level of service regardless of variables in specific conditions (such as weather, accidents) in near real time. This also provides a clue to road users of overall demand and conditions on alternatives, as the higher the price, the more likely is it that alternatives are significantly inferior in terms of travel time.

For dynamic pricing to work effectively requires the following characteristics:

- There must be price certainty when price is notified to the driver. The price offered must be the price paid by the motorist at the time of using the road. This means the driver must be aware of the price at the time of choosing to use the route, so the driver can choose to continue to drive or to choose an alternative option.
- Price notification needs to be made in advance of the priced route so the driver can make an informed decision and consent to the price, with the final price notification by some form of electronic notification by signage at the final decision point before using the priced route. Awareness before starting a trip may be insufficient if the driver has to travel for some time/distance before reaching the priced road, during which time the price may have changed due to demand.
- Pricing must be able to be changed with little to no notice reflecting levels of demand if it is to strictly maintain levels of service.
- The choice of alternative must be easy and safe to make.

These characteristics exist for priced, managed lanes because the priced lanes simply provide a premium service parallel to unpriced lanes on exactly the same corridor. The default option is not to use the priced lanes, with the priced lanes available if the driver is willing to pay for the expectation of a faster, smoother drive. This choice is simple: use the priced lanes or remain on the unpriced lanes. This is much more complex and difficult for urban road pricing schemes that apply a price to all lanes on a route or routes to a destination. The alternatives of another route may not be available, and the alternative of another mode may not be apparent or convenient (unless a significant proportion of trips parallel a frequent public transport service). It is unlikely to be reasonable or safe to expect a motorist to choose at the final

second to stop or find somewhere to wait until prices drop to a level acceptable to the motorist.

For example, if there were a cordon around central Tauranga with dynamic pricing, and a motorist wished to drive from a home in Te Puna to employment in Mt. Maunganui in the AM peak:

That motorist may be able to check before departure what the price is *at that time* from home (say $2), but a dynamic pricing system may mean the price increases during the 15 or so minutes between home and the cordon (because many more vehicles crossed the charging point during that time). If the motorist approaches the cordon and is advised by an electronic sign of a new higher price (say $5) and regards the newer higher price as "unacceptable" what options does the motorist have? To divert along a much longer route may be too inconvenient, to stop to find a park for a bus service would require the availability of convenient carpark with high quality frequent services (to the required destination) to be desirable, and to change time of travel would also likely be inconvenient once the journey has begun (the motorist is unlikely to return home and waste more time).

It is unlikely that the motorist facing a higher price once reaching the cordon would change behaviour on that occasion. However, on a subsequent day the motorist would likely *assume* there would be a price range for the cordon at the time she wishes to travel. Then would decide whether to drive or not at that time (comparing travel time, route and modal choices based on an assumption of price, not the actual price). Therefore, the impacts of dynamic charging on regular road users would be quite limited, as they would choose to accept a range of prices for a specific time period and drive regardless. It is unlikely that there would be significant benefit from dynamic pricing over variable pricing.

Critical to the success of urban road pricing is for drivers to be able to make a relatively simple comparison of the costs of travel (both financial and in time, comfort factors) before making a choice about when and how to travel. Variable pricing can enable this, although it may not always ensure the target level of service at all times in ensuring a minimum level of service, it can do so on most occasions (as witnessed in Singapore), and it can allow for changes in pricing to adjust to changes in demand. Dynamic pricing does not enable a simple comparison to be made, but although it may help provide a minimum level of service, it would only be effective for discretionary trips at short notice for drivers whose journeys started adjacent to the charging point.

In theory, such a system could be augmented by enabling motorists to book slots, prepaying at a price based on forecast demand (with pricing increasing as more slots are booked). This would mean the system is dynamic at booking time (like airfares and hotel rooms) rather than dynamic at travel time. For example, this would have serious implications for people wanting certainty about the costs of their daily commute, which is likely to be highly controversial and unworkable.

Dynamically priced managed lanes operate well for two reasons:

- Optimising level of service for the managed lanes (as a premium product that is a choice);

- Optimising utilisation (and revenue) for the priced capacity (by enabling prices to be as low as is viable to encourage use during off-peak periods, and maximising revenue and lane throughput during peak periods).

Essentially, dynamically priced managed lanes operate in a quasi-commercial sense, in that they are capable of revenue maximising for the priced capacity, by balancing demand and price in real time. Although generation of revenue is the primary objective of some urban road pricing schemes, it is not in the context of revenue maximisation in the commercial sense.

Airlines operate a dynamic pricing model, albeit for reserving seats on flights. Their objective is revenue maximisation, which sees prices heavily discounted if demand does not meet forecasts, with literally dozens of fare class categories (for essentially the same product) ranging from deep discounts to full price. The goal being to maximise revenue from sales, not merely fill the flight. For roads, there is no system of reserving "slots" on the network, but if there were, it could be easy to deep discount motorists willing to book and pay early for non-refundable slots at busy times, and to charge very high prices for those turning up "last minute" to drive. Although all of this might be theoretically possible, it is difficult enough already to obtain public support, political consent and social licence to introduce basic variable urban road pricing.

It is notable that Singapore has 47 years of experience of urban road pricing (of which 20 years has been with electronic technology) and is currently implementing a GNSS (Global Navigation Satellite System) based next generation pricing system to replace existing technology, and is *not* considering dynamic pricing. Its current plans are to simply replace the existing system with new technology and deliver better trip data to drivers, with the flexibility to add new charging points (without the need for expensive fixed infrastructure) or introduce distance-based charging. Dynamic pricing is not being considered. Similarly, early discussions on options for a next generation system for London are talking of distance, time and location based variable charging, but not dynamic pricing. This indicates that both cities do not see sufficient merits in having prices change in real time, compared with expanding the scope and the levels of disaggregation (by location, time of day and direction of travel) of existing variable pricing schemes.

Importantly, for a city with residents that only have experience with conventional tolls, it would be a significant leap in sophistication and complexity to move to dynamic road pricing, having had no experience of variable road pricing by time of day, or even a more simple basic peak price only scheme (see Figure 6). A shift to peak only tolls or a Stockholm/Singapore level type of variable pricing would be a significant advance on the status quo. Note that The Congestion Question has *not* progressed dynamic pricing, in part because of the difficulties in providing certainty to regular commuters as to the price of their commute, the lack of net benefits of dynamic pricing compared to variable pricing and also concern that radical shift from unpriced roads to dynamically priced roads, with no unpriced similar alternative would be unacceptable.

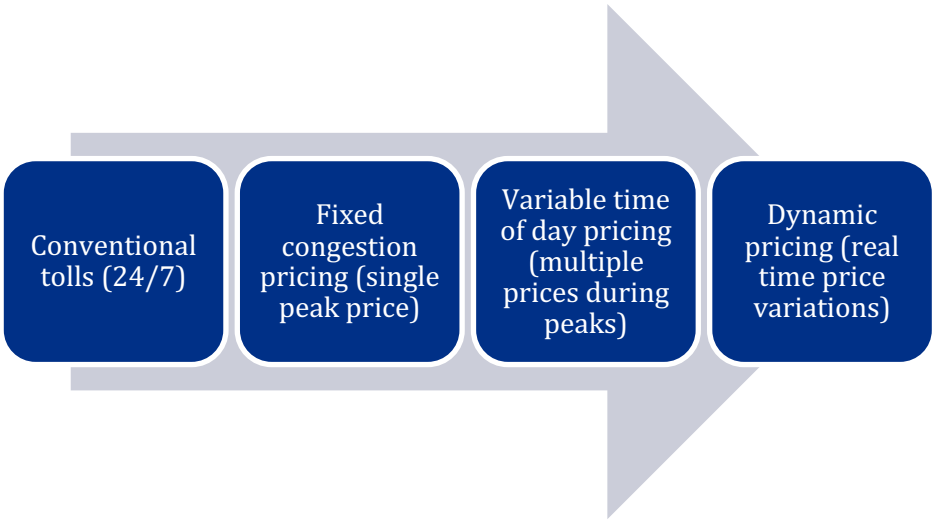

Figure 6 Levels of urban road pricing complexity

1.4 Characteristics of cities with urban road pricing

Background

Fourteen cities have urban road pricing systems on existing roads.[6] Of those, all but London, Dubai and Seoul include cordons, whereas Dubai and Seoul[7] consist of corridor charges (Singapore, and the cities in Norway and Sweden with urban road pricing have both cordons and corridor charges). Figure 7 identifies those cities, as well as several cities (Brussels, Doha, Hong Kong and New York) which have announced an intention to progress with urban road pricing.

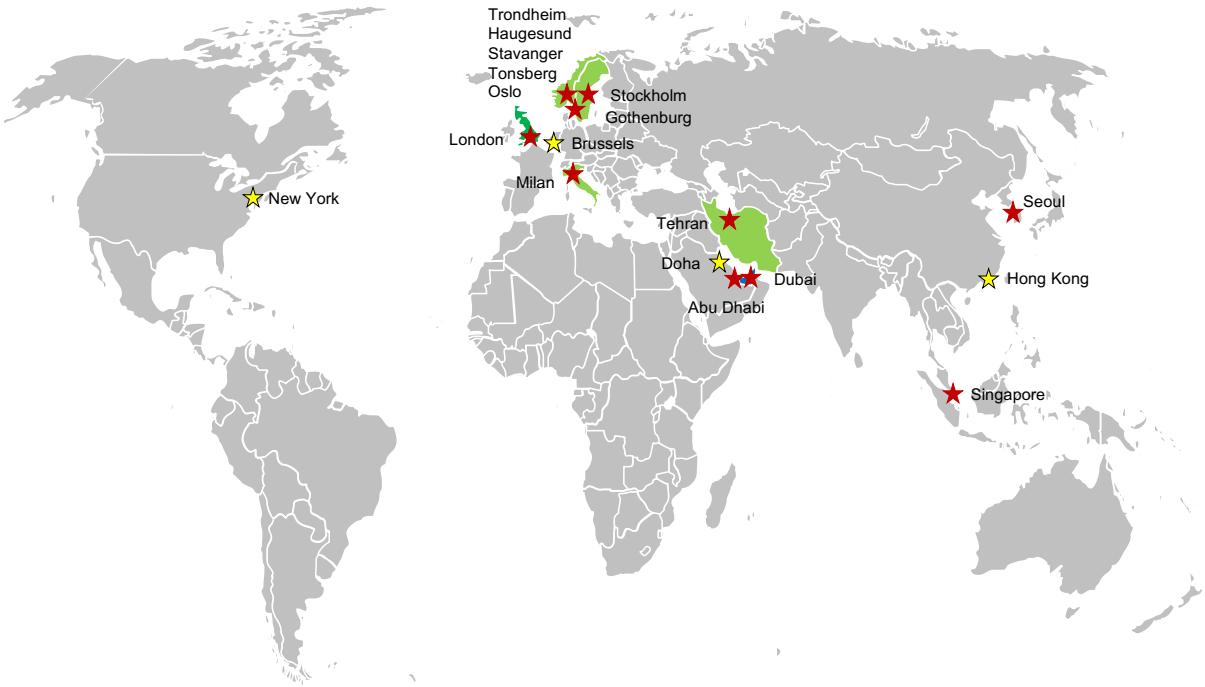

Figure 7 Cities with urban road pricing and announced intention to introduce road pricing

The cities with existing systems (excluding those with managed price lanes) are summarised in Table 1 below. This outlines at a high level how each city's scheme works (the degree to which charges vary by time of day or location), the primary objectives of each city scheme, and the scale of implementation (and type of road pricing scheme introduced or planned, according to the scheme types described above. Most have a mix of cordon and corridor charges, with a range of primary objectives, although most only have a simple structure of variable charges with charges during peaks that are higher than interpeak charges. Higher levels of charge disaggregation are seen only in Singapore, Stockholm and Gothenburg (which have a range of charges through peak and off-peak periods designed to spread demand).

City	Functionality	Objectives	Scale
Singapore	Charges vary by time, location and direction of travel	Congestion	Central city and main corridors

[6] Excluding two cities with historic urban centre protection-based schemes (Durham and Valetta) and two smaller Norwegian cities with urban cordons that operate 24/7.

[7] Seoul has congestion pricing on two tunnelled highways within a single corridor (Namsan #1 and #3).

Oslo	24/7 charging with peak fees	Revenue, emissions, congestion	Triple cordon from inner city to outer suburbs
London	Flat charge 0700-1800 weekdays,1200-1800 Sat/Sun	Congestion[8]	Area of central city only
Stockholm	All day, higher at peaks than interpeak	Congestion	Cordon and one corridor (central city)
Gothenburg	All day, higher at peaks than interpeak	Revenue	Inner city cordon and two adjacent corridors
Milan	All day flat charge	Emissions	Central city cordon
Abu Dhabi	Peak only charges	Congestion	Central city cordon
Dubai	24/7 charging	Congestion	Seven corridors
Seoul	All day charging (HOV exempt)	Congestion	Two corridors
Stavanger	All day charging with peaks	Revenue	17 corridors
Trondheim	All day charging with peaks	Revenue, emissions	Eight corridors
Tonsberg	All day charging with peaks	Revenue	Outer cordon
Haugesund	All day charging with peaks	Revenue	Seven corridors
Cities considering road pricing			
New York	All day charging with peaks	Revenue	Central city cordon
Brussels	24/7 charging by distance with peak charges	Congestion/ emissions	Full network
Doha	All day charging	Congestion	Cordon
Hong Kong	Peak only charging	Congestion	Cordon
Auckland	Cordon/corridor	Congestion	Inner city cordon and corridors

Table 1 Functionality, rationale and scale of cities with urban road pricing

What types of cities introduce urban road pricing?

Although some of the cities most well-known for urban road pricing (i.e. London, Singapore, Stockholm) have populations well beyond that of Tauranga's current and projected population, notably higher population densities and concurrent high frequency public transport services, there are a handful of cities with lower populations and densities (and public transport service provision) with urban road pricing and many large, high density cities without urban road pricing.

Urban road pricing is comparatively rare internationally, because the primary barriers to its introduction are not technical or even geographical, but rather public acceptability (which is a function of policy and concept design, and clarity of objectives and communications) and political will. One of the key early conclusions of The Congestion Question work in Auckland was that public acceptability was the critical factor that saw urban road pricing policies be advanced to implementation or be stalled and abandoned (even following several years of planning and previous political agreement to proceed).

Leaving aside the complex issue of developing and sustaining public acceptability (and political will), there are some characteristics common to virtually all cities that have introduced urban road pricing schemes:

- Road use trip patterns have regular peaks of demand by time and location;

[8] Hours have been extended beyond congested times to raise revenue.

- Traffic congestion is widely accepted as a serious problem, unable to be resolved by simply building new road or public transport supply; and
- Sufficient geographic concentration of trips at peaks to enable an initial implementation of urban road pricing to have some demonstrable effectiveness.

The last point is notable, whether it be a central city area or a specific corridor (e.g., Seoul has only introduced pricing on two tunnels), the road network geography and trip patterns need to be sufficiently concentrated (and constrained) at specific points, corridors or areas to enable a concept to be implemented as a first step and be effective. In many cities this initial implementation may be the end point (see London, Gothenburg, Milan, Dubai), for others (Singapore, Stockholm, Oslo) the scheme geographical scope expands over time to respond to traffic issues more widely.

Table 2 depicts the population, population density and private car mode share for commuting, for cities with or considering urban road pricing. Population essentially illustrates potential for trip volumes, population density the concentration of trips by origin/destination and potential for modal shift, and private car mode share illustrates the proportion of trips that are taken by public transport and active modes.

Although most cities with urban road pricing have higher populations and population density than Tauranga (with lower mode shares for private cars, several have lower populations and densities (notably smaller Norwegian cities).

Most cities with urban road pricing have much lower commute mode shares for private cars (including passengers) than Auckland or Tauranga, though some have mode shares ranging from 60-70% (particularly the smaller Norwegian cities and Gothenburg). It should also be noted that the *proportion* of private car trips in cities with urban road pricing that are captured by road pricing schemes is in many cases, not high. This is because such schemes typically focus on the most congested roads at congested times, so many trips can be undertaken in other locations and in the busiest locations at off peak times.

Many urban road pricing schemes apply to a relatively small geographic areas (e.g., London's congestion charge covers 1.3% of the metro area) and proportion of city traffic (8% of distance travelled). Similar conditions apply in Stockholm (20% of trips subject to the charge) and Milan, but in Gothenburg the pricing scheme is proportionately larger in its scale than those cities (see Figure 8). Although no statistics have been sourced for the proportion of vehicle trips captured by the Gothenburg scheme, it is likely given the traffic volumes on the routes that are charged, to be approximately 40-50% of trips during an average weekday.

Figure 8 Gothenburg congestion pricing scheme (circle is the CBD, dotted circle is the main traffic bottleneck (pre-charging)

Singapore and Oslo also have urban road pricing schemes on a relatively large scale, as Singapore has expanded its Electronic Road Pricing (ERP) scheme to address to traffic congestion beyond the inner city, so that all major corridors leading towards the central city have congestion pricing (see Figure 4). Oslo's scheme has expanded in recent years to implement three sets of cordons (with corridor charges) that now charge around 75% of traffic circulating during weekdays in the Oslo metropolitan area (see Figure 2).[9]

City	Metro pop.	Metro pop. Density	Private car mode share (commute)[10]
Singapore	5.5m	7,804 km^2	22%[11]
Oslo	1.6m	3,867 km^2	30%[12]
London	14.4m	1,510 km^2	37%[13]

[9] Source: http://www.trafikk.info/2017-06-08%20Oslo/07%20Road%20Pricing%20and%20Charging%20in%20Norway%20(Kristian%20Warsted).pdf
[10] Pre-Covid, excludes taxis and private hire vehicles.
[11] Source: https://www.singstat.gov.sg/find-data/search-by-theme/population/mode-of-transport/visualising-data/mode-of-transport-dashboard
[12] Source: https://citytransit.uitp.org/oslo
[13] Source: https://www.london.gov.uk/questions/2020/33

Stockholm	1.6m	4,175 km^2	43%[14] (metro, 22% at cordon)
Gothenburg	1.1m	1,300 km^2	74% (at cordon/corridors)
Milan	4.3m	2,055 km^2	59%[15]
Abu Dhabi	1.5m	1,600 km^2	72%
Dubai	3.5m	860 km^2	61%
Seoul	26m	8,300 km^2	26%
Stavanger	0.3m	2,871 km^2	57%[16]
Trondheim	0.3m	557 km^2	57%[17]
Tonsberg	0.1m	367 km^2	62%[18]
Haugesund	0.04m	564 km^2	66%[19]
Cities considering road pricing			
New York	20.1m	2,053 km^2	38%
Brussels	2.5m	7,400 km^2	50%[20]
Auckland	1.7m	1,210 km^2	66%[21]
Tauranga	0.2m	1,094 km^2	80%[22]

Table 2 Cities, population, and mode share

[14] Source: https://www.sciencedirect.com/science/article/pii/S0966692319305447
[15] Source: https://www.researchgate.net/figure/Modal-split-in-the-Milan-Metropolitan-Area-baseline-case_fig2_352878210
[16] Source: https://uis.brage.unit.no/uis-xmlui/bitstream/handle/11250/2682028/Thesis%20PDF.pdf?sequence=1&isAllowed=y
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[20] Source: https://journals.openedition.org/brussels/1696#tocto2n5
[21] Source: https://at.govt.nz/media/1985132/census-snapshot-brochure.pdf
[22] Source: https://www.nzta.govt.nz/assets/resources/keeping-cities-moving/BoP-regional-mode-shift-plans.pdf all of BOP region and is an aspirational target for PT and active modes for Tauranga.

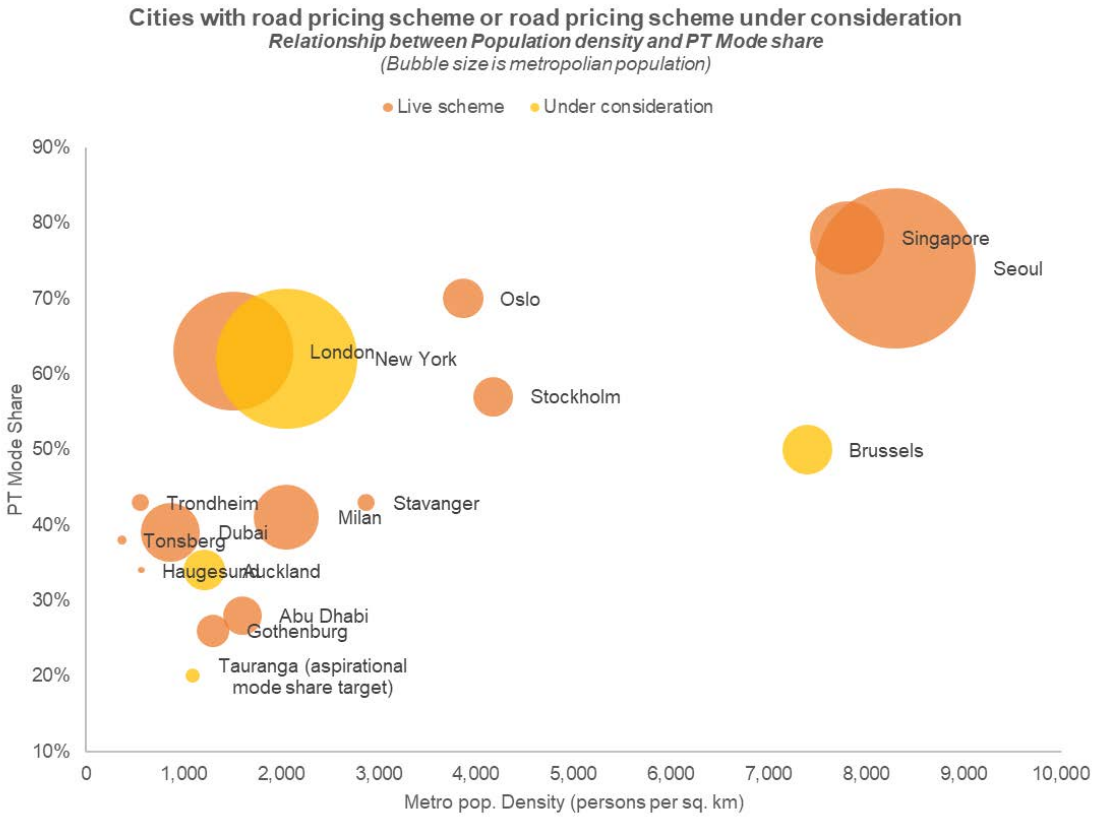

Figure 9 Population, density, and mode share of cities with urban road pricing

Outside Norway (which has had a political consensus on tolling and urban road pricing, primarily to fund urban transport improvements, although not without controversy), urban road pricing has proven extremely difficult to progress in most countries, especially for the primary purpose of raising revenue. The introduction of the London congestion charge generated some interest in studying congestion pricing in multiple UK cities, but public opposition saw serious proposals in Edinburgh and Manchester collapse (and the initial expansion of the London scheme (the Western Extension) was reversed within a few years due to opposition). In Sweden, although the Stockholm congestion tax was introduced with a bare majority of public support, the Gothenburg congestion tax was introduced despite significant public opposition, primarily as a taxation measure. Efforts to introduce congestion pricing in the Netherlands and Finland have failed due to public concern that pricing would cost them while generating significant negative impacts for some road users and businesses.

Norwegian cities

Although there are differences in average incomes, geography (and quality of public transport provision) in the smaller Norwegian cities, the experiences of those cities indicates that population and population density are not barriers to introducing urban road pricing to a scale that fits the needs of the specific city. Although in all cases, a good standard of public transport is important, this also varies in type and scale. Haugesund, Tonsberg and Stavanger having conventional urban bus services, with Trondheim recently having introduced bus rapid transit and Oslo with networks of metro, suburban rail, tram and bus services.

The Norwegian cities have all implemented urban corridor and cordon schemes that operate all day on weekdays, with higher charges during the peaks. Trondheim first introduced a

cordon in 1991 to fund a series of road improvements, charges were removed in 2005 (after the capital costs of the improvements had been recovered) but reintroduced in 2010 in order to reduce emissions, congestion and fund further improvements to the transport network (roads, public transport and active modes).

This indicates that with appropriate improvements to public transport and active modes, it is possible for cities to be able to provide alternatives that enable urban road pricing to be introduced that do not seriously disadvantage those that need to travel at times when pricing is in operation. In all of the Norwegian cities, the political consensus on urban road pricing is an extension of a national policy that has supported the use of tolls more generally to help fund major highway infrastructure. However, it is important to not under-estimate the increasing difficulties in Norway in introducing new urban road pricing schemes in recent years. It has become increasingly controversial, with the Norwegian Public Roads Administration recently trialling in-vehicle units to replace tolls and urban road pricing schemes with distance, time and location-based road user charging. Appendix 1 contains maps depicting the charging scheme geography of several Norwegian cities.

1.5 How do objectives affect road pricing scheme design?

Although most urban road pricing schemes are expected to deliver on multiple objectives, virtually all urban road pricing schemes focus on one of three primary objectives:

- Congestion reduction
- Revenue generation
- Emission reduction to improve air quality

Related to those objectives may be others, such as improving the performance of public transport networks, improved urban amenity and encouraging changes to urban form, but to date all operating urban road pricing schemes have had a focus on one or more of network performance, revenue generation and improved environmental conditions.

Table 1 depicts the primary objectives of urban road pricing schemes in operation, noting that some of these have evolved over time, and many have more than one objective, but all tend to prioritise one major objective over all others.

The essential characteristics of urban road pricing schemes are that they will reduce demand for road space for the vehicles subject to the schemes at the times and locations they are charged (and with effects beyond charging points as demand changes and affects roads approaching charged locations). This reduction in demand sees four primary impacts on travel:

- Modal shift (so the same trips are undertaken using different modes);
- Time shift (same trips are undertaken during times of lower or no pricing);
- Route shift (same trips are undertaken but re-routed on unpriced routes or to minimise prices paid); and
- Trip consolidation (fewer trips are undertaken in the charged location).

The relative proportions of these changes depend very much on the road pricing scheme design details (by type, geography, time of operation and prices charged), the availability and attractiveness of alternative modes or routes, and the purposes of trips taken on the priced roads. For example, post-implementation analysis of Stockholm's congestion tax is estimated to have seen about 40% of the drop in car trips during the charged period to have shifted mode, 24% of trip reduction is due to reduced frequency of travel, 6% shifted route (to the unpriced bypass motorway) and around 20% "disappeared" (believed to be trip consolidation).[23]

Alongside reduction in traffic comes reductions in congestion and improvements in trip reliability. Reductions in traffic and improvements in the flow (and reductions in fuel consumption) of remaining traffic will reduce emissions (improving air quality and reducing contributions to climate change). Finally, it is clear that charging a fee generates net revenues

[23] Source: https://transportportal.se/swopec/cts2014-7.pdf p.14.

(assuming it is done with a basic level of operational efficiency), regardless of this being the primary objective.

The purpose of this section is to describe how these objectives affect how urban road pricing schemes are designed and operated.

Congestion reduction

Schemes in Singapore, Stockholm, Abu Dhabi and Seoul are primarily focused on congestion reduction. A focus on congestion reduction tends to mean scheme design that is more refined and focused on improved network performance. Singapore takes the most sophisticated approach to this, with specific traffic speed performance targets, and with highly refined pricing by location, direction of travel and time increments. The key elements of the Singapore scheme that directly reflect its objective of congestion reduction are:

- Pricing that varies by specific road location and direction of travel (depends on demand and capacity at each location);
- Pricing that varies by time of day/day of the week increments for each location and direction of travel (depends on demand and capacity at each location by time of day)
- Pricing that reflects vehicle size (depends on road space occupancy as a factor contributing to congestion);
- Quarterly revisions of prices at each location/time increment to reflect network performance at each location (with prices varying up, down, removed or expanded in time of operation/direction depending on network conditions).

Stockholm also has refined pricing increments by time of day and location (albeit only one location variation, as there is a price for the cordon and a separate price for the Essingeleden through route). Prices have been revised twice since the scheme was introduced to reflect inflation and growth in demand. Essingeleden (see

Figure 1 the route passing through the cordon) did not have a fee applied until 2016, which was introduced specifically because congestion had become severe on that route (which is the only route for through traffic not entering the city). Stockholm has increased fees twice (2016 and 2020), changed operating hours and introduced seasonal variations in fees as follows:

Congestion levels vary during the year. In late spring, and in summer and autumn, traffic density and congestion levels are generally higher than in winter and early spring. The congestion tax will now be adjusted to these variations with the introduction of a peak season and an off-peak season.[24]

Abu Dhabi is a new scheme that has only been in operation since January 2021. Seoul's scheme has existed for many years (since 1996) but appears only to have revised fees twice in that time (the latest to encourage low emission vehicles), with little information available on the system performance.

[24] Source: https://www.transportstyrelsen.se/en/road/road-tolls/Congestion-taxes-in-Stockholm-and-Goteborg/congestion-tax-in-stockholm/stockholm-congestion-taxes-modified-on-1-january-2020/

However, common to both systems is:

- Location targeting of routes that have poor network performance or contribute significantly to congestion on adjoining networks;
- Time of day targeting of traffic (avoiding off-peak periods without congestion).

Revenue generation

Notable urban road pricing schemes focused on revenue raising are Gothenburg and Oslo (indeed all of the Norwegian schemes have revenue as a key if not primary focus). New York's proposed lower Manhattan scheme is also motivated heavily by desire for revenue to support improvements to public transport.

For almost all schemes revenue raising is always seen as at least a secondary positive outcome from road pricing, even from schemes that predominantly exist to improve network performance. However, when an urban road pricing scheme is designed to prioritise revenue raising, this affects key elements of the design.

Gothenburg, although designated a congestion tax (to fit within the legal framework of the law on congestion taxes for Sweden), was designed primarily to raise revenue for a package of transport network investments. Before pricing, congestion in Gothenburg was focused primarily on bottlenecks at peak times (see Figure 8), but the chosen cordon scheme has a wider geographical and temporal scope than just the E6, E20, E6.21 (Lundbyleden) junction area at the AM and PM peak periods.

Gothenburg's congestion tax applies all day (06:30-18:30) and across many locations that have little to no congestion. The cordon applies to the CBD and the inner suburbs, with two additional corridors subject to the fee (E6 north and Älvsborg Bridge). This enables the scheme to generate the revenue required to help fund the package of transport improvements (known as the West Swedish Agreement).[25] Gothenburg has designed the scheme to maximise revenue, rather than target congestion. This has resulted in criticism of the fee being a "tax on mobility", including an economic appraisal indicating that there were negative outcomes for all income groups paying the fee.[26]

Oslo's urban road pricing scheme has operated for many years, and started as a flat fee with manual toll collection in the early 1990s for a single cordon, and now has peak charges (and off peak charges), across three cordons, with fully electronic collection. When it was introduced in 1990, it was intended to assist funding "Oslo Package 1" of transport improvements, primarily to build a network of bypass tunnels to take through traffic off of surface streets. In 2001 it was supplemented by "Oslo Package 2" which primarily consisted of a series of public transport improvements. As all forms of tolling in Norway are governed by law that requires tolls to be removed once projects are paid for, Oslo subsequently announced "Oslo Package 3" in 2008, as a series of further capital projects for both roads and public transport, alongside reforming the urban road pricing scheme to also target congestion. "Oslo Package 3" extends till 2032 the package of projects that the urban road pricing scheme

[25] There has been some controversy over the transport package, due to a significant portion of the cost being dedicated to rebuilding the central railway station to support increased intercity passenger rail capacity, which delivers few benefits to commuters paying the congestion tax.
[26] Source: https://link.springer.com/article/10.1007/s11116-017-9853-4

will pay for. It is worth noting Oslo's scheme operates 24 hours a day, 7 days a week (although the other Norwegian schemes listed only operate during weekdays during peaks and interpeak periods), primarily to meet revenue requirements.

New York's proposed Lower Manhattan scheme is planned to also operate 24 hours a day, 7 days a week with higher peak charges. This is also designed explicitly to raise at least US$800m per annum to pay for subway capital spending, so is planned to operate at all times (albeit those that already pay tolls on river crossings to the charged zone will have the tolls they pay credited to the scheme fees paid).

Emissions reduction

Almost all urban road pricing schemes are understood to contribute towards objectives of reducing emissions, but only one is notable as focusing on emissions as a primary objective – Milan. Milan's scheme (called "Area C") grew out of a low-emission zone (Ecopass 2008-2012) which itself had previously been a restricted traffic zone (that limited vehicle movements to residents and vehicles with a business purpose in the zone). It reportedly resulted in an 18% reduction in PM10 within the cordon, largely matching the reduction in vehicles entering the cordon after it was introduced (noting this was a reduction on top of what had been experienced by the low-emission zone that it replaced). Milan's scheme has the following key characteristics:

- Operations all day on weekdays;
- Prohibitions on higher emitting vehicles;
- Exemptions on zero emission vehicles;
- Certain exemptions for "service" vehicles and deliveries of certain commodities (e.g. perishable goods); and
- Different rules for residents' vehicles.

A focus on emissions reduction sees less interest in applying charges only at peak times or in improving network performance, but rather to reduce overall traffic volumes (with discounts or exemptions for zero or ultra-low emission vehicles). Assessment of Milan has focused predominantly on reductions in emissions.[27] Although Milan also generates net revenues, its focus on environmental outcomes is notable by its annual scheme review reporting on traffic volumes and emissions, not revenue. It also has a comprehensive schedule of restrictions and variance of fees based on vehicle emissions categories. Revenue for the Milan scheme has been relatively stable whilst it has been in operation, reflecting that it has largely kept traffic at stable levels, as it combines restrictions on classes of vehicles using the scheme, with fees targeted to encourage use of low emission vehicles.

[27] See https://www.researchgate.net/profile/Sunny-Kodukula/publication/325987968_The_Ecopass_pollution_charge_and_Area_C_congestion_charge_-_comparing_experiences_with_cordon_pricing_over_time/links/5b31eed00f7e9b0df5cba0e3/The-Ecopass-pollution-charge-and-Area-C-congestion-charge-comparing-experiences-with-cordon-pricing-over-time.pdf?origin=publication_detail and https://nws.eurocities.eu/MediaShell/media/Milan%20congestion%20charge.pdf

Current ban	1/10/2022	1/10/2024	1/102027	1/10/2029
<Euro1 (petrol) <Euro4 (diesel)	Euro2 (petrol) Euro4 (diesel retrofitted) Euro5 (diesel)	Euro 3 (petrol)	Euro4 (petrol)	Euro6 (diesel)

Table 3 Milan Area C private vehicle restrictions[28]

In summary, the key elements reflecting Area C's focus on environmental outcomes are:

- A single all-day fee for access for eligible vehicles (indicating that the type of vehicle and emissions category is more important than the frequency of travel)
- Prohibitions on higher-emitting vehicles (with such prohibitions being broadened in future years to encourage only use of the newest, lower emitting categories)
- Electric and hybrid vehicles are exempt (unlike in Stockholm, Gothenburg or Singapore).[29]

Conclusion

All urban road pricing schemes contribute to reducing congestion, generating net revenues and improving environmental outcomes. However, the relative priority of objectives affects scheme design of various elements. This is illustrated in Table 4.

Objectives	Time of operations	Geographic scale	Scheme type	Discounts/ exemptions	Rate structure
Congestion relief	Peak demand	Targeted by bottlenecks	Corridor, cordon	Minimal exc. buses	Highly disaggregated
Revenue generation	All day	Necessitated by revenue target	Area, cordon	Minimal	Simple
Emissions reduction	All day	Location of poor air quality	Area, cordon	Low emission vehicles	Varies by emissions category

Table 4 Effect of objectives on scheme design

[28] A comprehensive list of these categories covering heavy vehicles, buses and residents' vehicles is available at https://urbanaccessregulations.eu/countries-mainmenu-147/italy-mainmenu-81/lombardia/132-countries/italy/lombardia-region/1549-milano-area-c-low-emission-zone-charging-scheme

[29] London exempts zero-emission vehicles only, as emission reduction is a major objective of the current Mayor of London.

1.6 Implementation Considerations

Key stages

Congestion pricing is not a transport policy project that is "conventional" like transport infrastructure construction projects, or even amendments to pricing of on-street parking or public transport ticketing. Globally, most transport projects commissioned by road controlling authorities or urban transport authorities comprise of the construction of infrastructure such as roads, bridges, railway lines or stations, or commissioning new public transport vehicles, ticketing systems or related systems. Systems that involve measuring use of transport infrastructure and services and charging users for that use, such as parking fees or public transport ticketing are widespread and have been in place for many decades in one form or another, and users expect to have to pay for such services.

Urban road pricing has many parallels with tolls, with a key difference that in most cases tolling systems are installed on a road at the point of construction (and replaced as technology reaches the end of its economic life). Road pricing also has parallels with Intelligent Transport Systems which are built into new highways to identify and warn motorists of changing conditions, such as weather, accidents, lane closures or changes in speed.

The key differences between tolling and urban road pricing from an implementation perspective are:

- Tolls are introduced at the time a new road (or lane) is opened. This means toll infrastructure can be installed at the same time as other highway infrastructure, and be integrated in the new road, rather than be retrofitted on an existing route. Tolls are much easier for the public to understand and accept, as they are presented as an option to pay to use a facility that previously did not exist. The option of *not* paying and continuing to use previously available roads (or lanes) makes tolling easier to implement from a public acceptability/political point of view and much less controversial, compared to urban road pricing which introduces a fee on a road that was previously not subject to one. Central to this is public scepticism that any form of pricing will make travel conditions *better* overall, especially for those subject to the fee (as few motorists typically believe that paying for a facility is anything other than revenue collection rather than managing demand).

- The impacts of urban road pricing are more significant than tolls on a new facility. Urban road pricing will change pre-existing behaviour, resulting in some trips being driven at other times, or on other routes, or by other modes, and may result in some trips being suppressed altogether. The positive impacts of this on reducing congestion (and pollution) may be significant, but if designed poorly, there may be negative impacts on drivers who have no alternative, but who may find the benefits in travel time savings and trip reliability do not outweigh the costs to them, potentially reducing their access to employment or education.

- Tolls in most cases operate 24/7, and only in some locations is there pricing that might vary by time of day (e.g., Sydney Harbour Crossings cost $1 more in the AM and PM peaks compared to interpeak). Urban road pricing only operates at times of peak demand and may only operate in one direction of traffic flow (typically inbound AM peak, outbound PM peak). It may also have prices that vary at several intervals during the day (e.g., see Figure 5 for the range of prices at just one charging point for

Singapore). This is more complex for the public to understand and respond to, and more complex to communicate (and can result in higher costs for customer management when motorists do not notice they have travelled at times of peak charges)

- Introducing pricing on *existing* roads will typically result in some relocation of trips that seek to avoid charging points (diversion), depending on the design of the scheme. Careful design choices may be made as to the location of a charging point to minimise this having a particularly negative impact, and a combination of traffic management measures (speed limits, traffic calming) or applying business rules to such trips, can also address such issues. Uncharged bypass routes are sometimes implemented (such as a ring route around a cordon, or an uncharged through route (with charges for vehicles exiting the route at some points)) so those with fewer alternatives (mainly because public transport usually cannot serve through travel as effectively as suburb – city trips) are not unduly affected. Conditional charge rules (such as has been implemented in Backa in Gothenburg) can be applied that mean that a charging point is only operational if a motorist crosses a control point first (to seek to capture trips that may divert to avoid a fee on a specific route, without charging a fee for local trips).

- For tolls the alternative is the untolled route, for urban road pricing the alternatives are changing time of travel, route of travel, mode of travel or whether to travel at all to the location accessible only by the charged road. Typically, the introduction of urban road pricing in parallel with enhancements to public transport (e.g., London and Stockholm both significantly increased bus service frequencies) to accommodate modal shift and improve public acceptability, although around half of shift in demand is usually by time of day or in consolidating trips (driving less frequently).

Although the implementation of urban road pricing may be divided into multiple workstreams through a detailed project plan, at a high level there are generally three main types of activity associated with implementing such schemes:

- Governance arrangements: Defining the legislative framework to authorise pricing, and the entity ultimately responsible for procuring and implementing the system. This includes management of the scheme, including use of net revenues, and the role of the private sector in supplying and operating services.

- Approvals: Assuming there is a legal framework to enable pricing, approvals are required from decision-makers to undertake detailed design and installation of the scheme, including undertaking public consultation, resource consents and a detailed business case.Approvals may also include the procurement approach, including whether such a scheme is simply an addition to any that may already be in place (Gothenburg was effectively an extension and variation of the Stockholm scheme, with shared account management and customer service functions).

Construction/installation: Once approvals have been obtained, the relevant governance agency (e.g., road controlling authority) would be expected to procure the installation, testing and operation of the scheme. This includes installation of roadside equipment and delivery of customer service functions.. The other critical activity is communication with the public on how to interact with the forthcoming scheme and what it means for them.

Governance: In the context of Tauranga, governance refers to the legislative and institutional framework within which urban road pricing would operate. It is understood that the Government is still developing this for legislation that could apply to cities across the country. In Tauranga it is clear that there are multiple government entities with some interest in the governance of an urban road pricing system, including Tauranga City Council, Western Bay of Plenty District Council, Waka Kotahi and Environment Bay of Plenty. Waka Kotahi being responsible for two toll roads and other state highways, and Tauranga City Council for virtually all local roads being considered for pricing are logical contenders, although option analysis has not been undertaken, rather the issues needed to be determined by suitable governance arrangements.

It is possible that if the Government's draft legislation for urban road pricing includes governance is should address issues such as:

- The entity responsible for procurement, ownership and management of the urban road pricing scheme (e.g., a road controlling authority or integrated transport authority);
- The entity responsible for reviewing and determining all elements of pricing;
- The management of net revenues;
- Decisions on disbursement of net revenues;
- Decisions on any changes to existing charges (e.g., tolls, parking);
- Responsibility for enforcement;
- Oversight and reviews of performance of the pricing scheme.

Determining these issues is critical to enabling the processes for approvals and construction to proceed smoothly, as well as ensuring clarity of responsibility. In every case of successful introduction of urban road pricing, governance issues have been addressed early (e.g., Singapore, Oslo, London, Stockholm, Gothenburg). In some cases that did not proceed, conflicting governance or governance by an entity with inadequate powers, responsibilities and incentives appears to have contributed to failure to obtain final public and political support (e.g., Copenhagen and Manchester).[30] Clarity of governance means that the responsible entity is able to make the decisions on design, communicate with the public and other stakeholders, and procure the necessary services/infrastructure to enable pricing to proceed.

Approvals

This includes all processes necessary to gain final approval to proceed with a mature design. It includes business case development, public consultation, planning approvals (for any construction) and any other processes defined by legislation as being necessary to implement a scheme. For example, in London, the proposed concept was modelled, with forecast impacts including revenue, and presented for public consultation on the proposed details of

[30] In Copenhagen, several small local authorities in metropolitan Copenhagen actively opposed the concept. In Manchester, the lead agency was, at the time, only responsible for procuring public transport services and infrastructure, and was not a road controlling authority.

implementation. That consultation was used to make some minor changes to the proposal (e.g., exemptions), but then proceeded. Approvals may not require detailed design but are likely to require a concept that defines where charging points will be located, and what sort of infrastructure is expected at those points. Again, legislation will define what these approvals are, both existing legislation (e.g., Resource Management Act) and the legislation that will be needed to authorise urban road pricing.

The single biggest risk in the approvals phase is public opposition. It is critical that adequate information is provided, clearly and concisely, so the public understands the objective of the scheme, how the scheme will meet that objectives and how its design and operation will minimise negative impacts and the risk of fraud. Scheme design needs to be sufficiently flexible to address negative impacts, and include complementary measures (changes to road layouts, public transport services) that support the scheme meeting its objectives.

Construction

The term "construction" here is used to include detailed design, procurement of infrastructure and services, installation, testing and inauguration of the road pricing system in operation. This also includes communications with the public, associated road infrastructure changes (signs, lining and changes to intersections etc. necessary to inform drivers and address expected significant changes in traffic flow). The scope of this will also be determined by the introduction of pricing in other cities and whether Waka Kotahi's tolling customer support and account management systems are to be used for the system (it is reasonable to assume this). If, as in Sweden, Tauranga is simply added onto a system established for one or more other cities, it is a simple case of adding and testing infrastructure but utilising existing systems to collect revenue from road users and supply customer service. If it is a bespoke system, procurement would be more complicated.

The biggest risk during construction is poor communication with drivers leading up to scheme operation. Providing adequate information months in advance of operation is essential so drivers do not seek to overwhelm the customer service function with queries or account registration only days out from the start of the scheme. This is to encourage frequent users to set up accounts, and for motorists to be clear about when and where charging will affect them. This information will be crucial to minimise people feeling "caught" by unanticipated changes or being confused near or on the day of introduction, and panicking either by diverting journeys or contacting the system operator to inquire as to "what to do". One way to enable this is to introduce the scheme during a quiet period (experience overseas is that school holidays outside peak holiday seasons can help) and have a campaign of information one or two months in advance, to ensure the greatest number of local motorists know what is coming and where. London was very conscious of this issue and embarked on regular communication with the public many months before the system was operational, and also set up a backup call centre to address any overflow of queries and issues in the early weeks of operation.

How was technical feasibility identified?

In most cases, technical feasibility for urban road pricing was based on a combination of the location of most severe congestion and concern, and the available technology at the time the scheme was introduced. Objectives were critical in determining this, and in more recent years it has not been technology that has been seen as the key barrier, but rather political will to implement some form of pricing.

Singapore: Singapore initially introduced a paper-based permit system (Area Licensing Scheme or ALS) in 1975, for an inner-city cordon. This was based purely on the available technology at the time and the greatest concern being the use of cars to access the inner city. The ALS provided the initial information about demand responses to pricing that was used to inform the subsequent evolution of the scheme over subsequent decades. ALS was followed in the 1990s by the Road Pricing Scheme and subsequently the now operational Electronic Road Pricing (ERP) system from 1998. Singapore identified the availability of technology for electronic detection of motor vehicles at the time as a means to save costs and enable significant scaling of the geographic and operational parameters of its road pricing scheme. The technology was adapted and designed specifically for Singapore, in part to support the city-state's objectives of presenting itself as a hub of technological and policy innovation. Extensive on-road technical trials were undertaken in advance of the decision to implement the ERP system. In the 1990s, traffic models were developed to simulate the impacts of pricing on demand and the assignment of that demand to different routes and modes, although the Singaporean Government accepted the fundamental principles of transport economics, that pricing would result in changes in demand from peak periods towards off peak periods.

London: The objectives for the London scheme were to implement a scheme in the most congested location within a three-year timeframe of the Mayor being elected with a mandate to introduce the congestion charge and demonstrating its effectiveness before the subsequent election. The area charge concept came about because it included the most congested network of roads in central London with the highest level of public transport service. An area charge was proposed because of the selection of ANPR technology, which at the time had relatively poor levels of accuracy (at the time Transport for London admitted that ANPR cameras would reliably identify around 60-65% of vehicle number plates with a single read). As ANPR systems required multiple images of the same vehicle to reliably identify a vehicle, it was decided to include cameras within an area, not just as a cordon, so that the average vehicle entering the charging area would have its number plate image taken on average 2.5 times (minimising the risk any single vehicle would not be identified). This was purely to enable reliability of operation. Cost was not important as net revenues were not considered to be the key objective (the primary objective was to reduce private car traffic to enable better flow of bus traffic and enable reallocation of road space to other modes).

Stockholm: The geography of Stockholm, with the central city area located on a large peninsula with three adjacent islands, provided the obvious location for a cordon-based scheme, with the Essingeleden motorway bypass along part of the north of the central area helping to define the boundary. With few entry points, and the concentration of public transport services (rail, tram and bus) on that area, it was technically simple to implement the proposed scheme. It was clear this concept would have a significant impact given the radial network of roads leading from the central area.

Stockholm implemented a seven-month long, fully functioning pilot of congestion pricing in 2006, which operated essentially as a fully-fledged (mandatory) road pricing scheme, before holding a referendum on whether it should be implemented permanently. Technical feasibility was tested during the pilot period, using, at the time, toll tags and ANPR cameras, to detect vehicles for invoicing. The pilot demonstrated that there was no need for toll tags given how reliable ANPR technology had become. However, the most important result of the pilot was proving how congestion pricing could work to reduce congestion in Stockholm.

A few weeks after it was introduced, traffic volumes crossing the cordon during charged periods were down by 20%, resulting in a 30-50% reduction in congestion within and approaching the cordon.[31] This dramatic impact (which was beyond expectations, as modelling had indicated the prices implemented would reduce traffic volumes by around 10-15%) demonstrated the technical feasibility for Stockholm. The subsequent public referendum saw a narrow "Yes" vote (53%) to introduce the scheme permanently, based no doubt on the experience of the impact of the pilot.

Gothenburg: Gothenburg followed on the success of Stockholm, but not because of the effects of pricing on congestion, but because Gothenburg local politicians were supportive of how Stockholm was leveraging future revenues in a deal with central government to enable significant capital spending on transport infrastructure.

From a technical point of view, it was accepted that the same technical solution as applied in Stockholm would be able to be implemented in Gothenburg (ANPR), using the same back-office and account management system used for Stockholm, as the same governance entity (Swedish Transport Agency) would procure and operate the system. However, the objective for Gothenburg were different from Stockholm. Gothenburg's scheme is designed primarily to raise revenue to support a large-scale transport infrastructure package, with congestion reduction a secondary objective. As illustrated in Figure 8, congestion in Gothenburg is concentrated on two major motorway junctions to the north of the central city, but a scheme on this scale (and operating only at the times during which severe congestion occurs regularly) would have been inadequate to generate the revenue sought.

As Gothenburg does not have the natural geographical barriers seen in Stockholm, designing the scheme geography was more challenging. The central city area straddled the Gote River, but in order to generate sufficient revenue, the cordon was designed with extension lines to the west and northeast to capture traffic travelling between suburban areas either side of the Gote River and the E6 motorway respectively. As a result. Gothenburg has 38 charging points compared to Stockholm's 18. The national transport forecasting model (known as SAMPERS) was used (not available for Stockholm in 2006). It is described as follows[32]:

SAMPERS consists of nested logit models for six trip purposes (Work, School, Business, Recreation, Social and Others), modelling choices of trip frequency, destination and mode (car as driver, car as passenger, public transport, walk and cycle). The demand models include private and business travel. Freight traffic OD matrixes are fixed (and thus assumed to be insensitive to congestion charge). There are three analysed time periods (morning peak, evening peak and off peak), over which demand is distributed using fixed time period factors per trip purpose applied uniformly to all origin-destination pairs. Road and transit link flows are calculated using the software package EMME/3.

This model was used to determine the optimal concept design to generate sufficient revenues, whilst focusing on the locations with the greatest congestion or potential for congestion.

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[31] Source: Eliasson, *The Stockholm congestion charges: an overview*, CTS Working Paper 2014:7.
[32] Source: Börjesson, *The Gothenburg congestion charge Effects, design and politics,* CTS Working Paper 2014:25.

How was operational complexity decided?

Following on from technical feasibility, operational complexity is generally a function of:

- Trade-offs of objectives (congestion reduction vs. revenue generation vs. other objectives)
- How important targeting the location and time of congestion is, and the profile of such congestion
- Previous experience of pricing
- Negative impacts that need mitigating by design.

In general, the introduction of a road pricing scheme in and of itself is a significant policy step for any city, and it need not be introduced at the scale that might be considered optimal from a transport economics point of view, but rather be allowed to operate and progressively evolve in scale and complexity. For Auckland, The Congestion Question (TCQ) project acknowledged that a first step for Auckland could be an inner-city scheme, followed by corridor -based charging progressively implemented over many years targeting congestion from inner towards outer suburbs. This is depicted in Figure 10. The most important step is implementing Phase 1, not because it will have the greatest impact, but because it demonstrates the potential of road pricing as a concept, and sets up the policy, practices, systems and public understanding of the concept that will allow it to be progressively expanded over time.

Please note that boundaries are indicative only

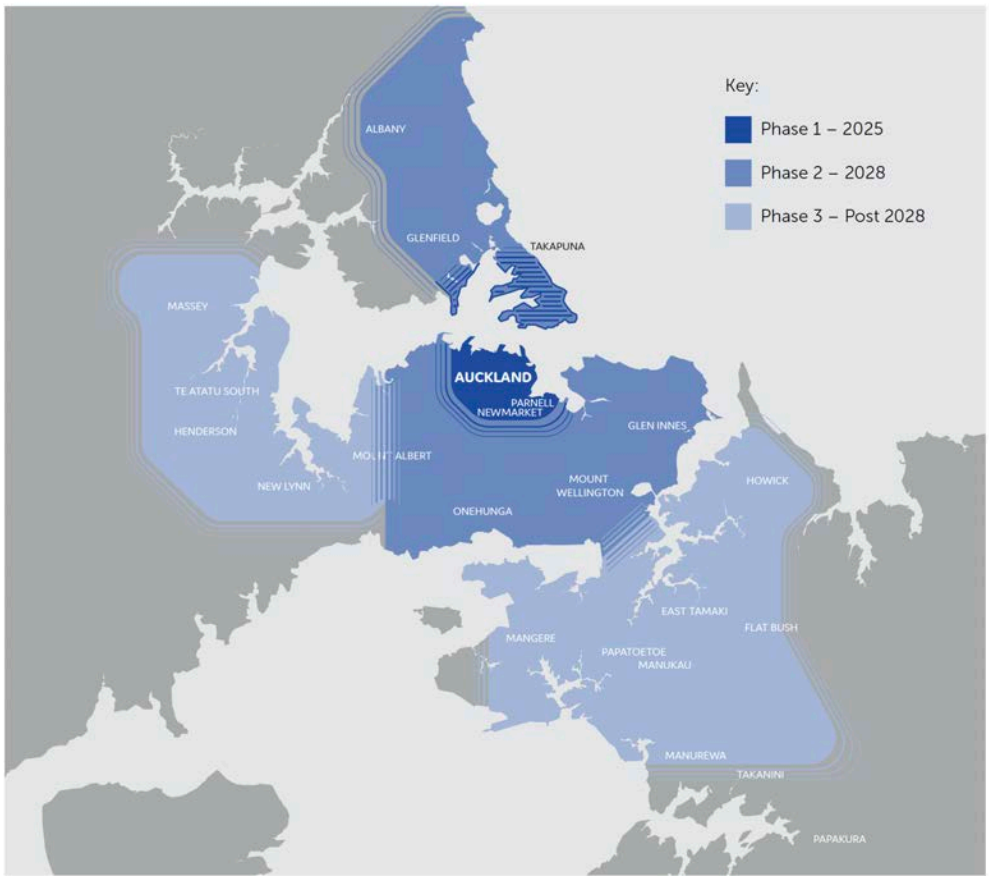

Figure 10 The Congestion Question proposed phasing of pricing

Singapore: Singapore demonstrates how a pricing scheme can be implemented relatively simply, but effectively at first (the Area Licensing Scheme in 1975 was notable for reducing peak traffic volumes by 60%).[33] Then progressively increased in sophistication over time, as it demonstrates its effectiveness and there is greater public understanding of the system. It is highly likely that very few Singaporean motorists know the prices for all times across all 78 charging points, but this is not important. They will know the prices for the roads that they use, and respond accordingly, either driving and paying (and expecting a high level of service) or driving at a different time, or less frequently or to a different destination (e.g., park and ride).

In starting with a simple cordon in 1975, Singapore had ample experience to build upon, by introducing a second cordon adjacent to the first one, and to follow with corridor charging. The push for electronic technology was not only to enable free-flow traffic and easier enforcement, but also enabled development of a prepaid stored-value transport smartcard for public transport AND the bespoke in-vehicle units designed for the electronic road pricing scheme. Such smartcards were designed to make paying for public transport, roads and parking much simpler and more efficient, and the technology chosen for Singapore's scheme was also designed to respect privacy (by enabling payment of pricing using the stored-value smartcard regardless of who owned the card or if it were registered).

Since 1998, Singapore has progressively increased the complexity and sophistication of its congestion charging system by:

- Adding charging points on corridors, at locations where congestion became sufficiently severe to justify pricing (and where it was practicable to introduce without causing significant traffic diversion). There are now 78 individual charging points on Singapore roads;
- Varying charge rates at each location by direction of travel and time of day;
- Introducing small increments of time to efficiently spread demand (see Figure 5), avoid peak bunching and encourage optimal use of existing infrastructure;
- Charging based on vehicle size (motorcycles at half the price of private cars, with trucks and buses two to three times).

[33] Source: *Electronic Road Pricing*, Land Transport Authority Singapore (presentation dated 2016).

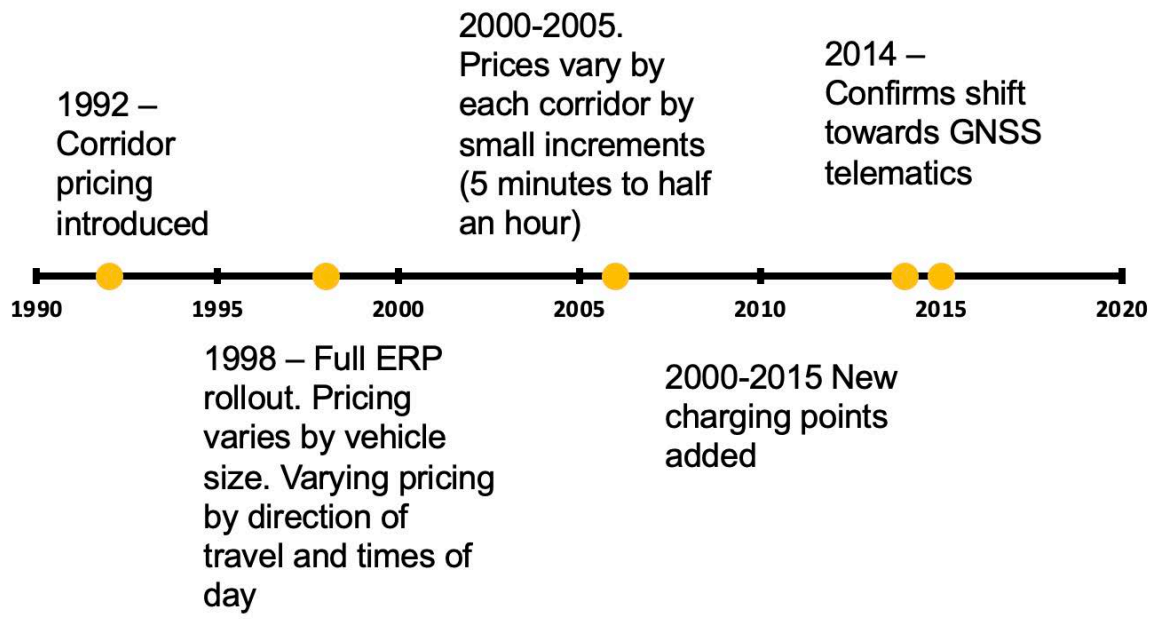

Figure 11 Timeline of Singapore system complexity

London: The political and policy imperative in London was significantly different from Singapore. In London the key constraints were the need to have a scheme operational for at least one year before the subsequent Mayoral election, this imposed conditions on the technology able to be used and the scheme concept, as it needed to be able to be implemented quickly and reliably. ANPR was selected because it would not require distribution of any equipment to vehicle owners and was necessary for enforcement.

In London, an area charge in central London was chosen because it was seen to be logical to focus on the slowest traffic area in London, with the densest network of public transport. A key trade-off of these choices was that the operating costs in the initial years were very high, with 47% of gross revenue lost in operating costs in the 2005 financial year.[34] This reflected use of live video feeds from all cameras, and a significant cost of manual number plate readings at the time. The other impact was that with an area charge, it is not feasible to vary charges by time of day (as only a single fee is charged per day to drive into the area), and it is difficult to expand without applying an equally blunt charge.

London has remained operationally quite simple since it was introduced, with a single fee, for all types of vehicles (that are not exempt or subject to a 100% discount), paying for an unlimited number of trips per day. The only expansion in operations have been in operating hours (to 1200-1800 in weekends) and the Western extension to the charging zone which operated from 2007-2011. Expansion of operating hours is relatively simple, as was the Western extension which simply applied the same charge to vehicles entering or circulating within both zones (with a single charge covering both zones).

Stockholm: The decision on Stockholm's cordon was largely made due to geography, which simplified the number of charging points needed, as the concentration of traffic congestion

[34] Source: Figure 93, *Central London Congestion Charging Impacts Monitoring, Third Annual Report,* April 2005, Transport For London.

was on the arterials approaching the central city area. An exemption for through traffic on a single motorway was introduced as a compromise for motorists without alternatives (as public transport focuses on radial trips) but has recently been removed (with a lower charge introduced for the motorway compared with entering the city) as pressure has grown to manage congestion on that route as well. A cordon was chosen because it provided the flexibility to charge by time of day, and focus on vehicles entering the central area, rather than those circulating within it. Stockholm could vary charges by entry point on the cordon but has decided not to, because of the relative effectiveness of the current scheme, and concern that having differential charges by location would be perceived as being unfair.

Gothenburg: Gothenburg followed Stockholm, but was designed on a scale needed to meet the revenue targets set (and reflecting modelling indicating how much traffic needed to be subject to pricing to meet the revenue goals). With operating hours from 0600-1830 weekdays, with charges varying between peaks and the interpeak period, the scale of scheme was expected to generate gross revenue of €93 million per annum (nearly NZ$156 million), to meet revenue demands. Notably this is greater than that for Stockholm (which was designed to manage congestion, whereas Gothenburg was designed to generate revenue). Gothenburg's scheme was originally a simple cordon as in Stockholm, with a daily cap on charges, but has since been amended to address some of the negative impacts of the scheme design:

- An hourly cap on charges has been applied, so that no one vehicle can be charged more than once during a 60 minute period, regardless of the number of charging points it crosses;

A conditional fee has been applied to charging points adjacent to the suburb of Backa, due to the effects of the fee on local residents accessing community facilities. In effect, only vehicles travelling from outside the community pass a detection point AND the charging point, will be charged.[35] [36]

How was social licence obtained?

Social licence for urban road pricing is difficult to obtain, as is seen by the dearth of cities that have implemented the policy, compared to those that have investigated it or even discussed it. It is notable that there is urban road pricing on a significant scale in only five countries in Europe (UK, Sweden, Italy, Norway and Malta), notwithstanding the significant commitment of the European Union towards reducing emissions from transport. Furthermore, in the United States, only New York looks likely to introduce pricing in the near future, despite extensive policy commitments in many other cities (e.g., San Francisco, Seattle, Boston) to reduce emissions, primarily due to the difficulties in obtaining public acceptability.

[35] This implements a conditional charging point, requiring a vehicle to be detected twice within 30 minutes (at two separate locations) before being charged. Any vehicle detected at any one of those points without being detected at the other within 30 minutes is not charged, which enables local residents to be exempt, but those transiting the local areas to access the charged road will be charged.
[36] More details on the Backa exemption are available at https://www.transportstyrelsen.se/en/road/road-tolls/Congestion-taxes-in-Stockholm-and-Goteborg/congestion-tax-in-gothenburg/frequently-asked-questions-about-the-exemption-for-congestion-tax-in-backa-gothenburg/

For those cities that have done so, there are some clear messages about what it takes to obtain social licence to implement pricing.

Singapore: Singapore's political culture is essentially one lead by implementing policies based on merit, although there is some sensitivity around public acceptability. As Singapore started in 1975 with the ALS, and demonstrated the effectiveness of the policy, it proved to be possible to expand with the ERP scheme. It is also notable that car ownership in Singapore is effectively restricted to those on higher incomes, because of the need to purchase a permit to own a car (Certificate of Entitlement) for ten years (which can be equivalent to the cost of the car itself). Singapore's per capita car ownership rate is 0.149 (cars per capita)[37] this compares to over 0.8 in New Zealand. Although a significant proportion of Singaporeans do not drive a car, the most powerful and influential ones do. A key element of continuing the social licence for the Singapore ERP scheme is its success in managing traffic flow and reducing congestion in the city-state. Its most recent technical evolution (ERP 2.0 – introducing GNSS based technology) reflects public interest not only in reducing congestion, but in replacing the large relatively unsightly gantry arrays located at charging points across Singapore. Ensuring that any roadside infrastructure is not unsightly will be an important consideration in enabling social licence in Tauranga (and examples exist in multiple cities of the types of ANPR camera systems that have less impact that has been seen in some of the older pricing schemes).

Figure 12 Singapore ERP gantry

London: In London, the first elected Mayor (Ken Livingstone) included explicitly in his policy platform a promise to introduce a congestion charge in central London. As he had the full legal authority to implement such a scheme, this was taken as adequate social licence to proceed. Despite some opposition, the scheme was introduced in 2003. In the 2004 election, Livingstone did not explicitly campaign to extend the scheme westwards to include much of Kensington and Chelsea, but did release a consultation document on the concept, inferring that it may proceed if he was re-elected (his main opponent campaigned on abolishing the entire congestion charging scheme). Having won re-election, Livingstone proceeded to expand the congestion charge to Kensington and Chelsea in 2007, notwithstanding that public consultation was overwhelmingly opposed the extension. In 2008, Livingstone lost the Mayoral election and his successor, Boris Johnson, had promised to review the extension. Following public consultation, it was abolished. London's congestion charge has largely remained as the original central scheme since then, with expansion of operating hours and

[37] Source: https://www.ceicdata.com/en/indicator/singapore/number-of-registered-vehicles

increases in the charge rate. More recently, Mayor Sadiq Khan has focused on implementing several Ultra Low Emission Zones, to reflect his policy focus on reducing noxious emissions, rather than traffic congestion.

Stockholm: Discussions about road pricing in Stockholm had emerged many years before it was piloted then implemented but were highly controversial. In the 1990s there had been discussions about using road pricing primarily as a source of revenue to fund new transport infrastructure, following the examples in Norway (notably Oslo) implemented at the time. In 2002, a central government report recommended road pricing to help fund new infrastructure in Stockholm, although this was rejected by the Mayor of Stockholm. However, the newly elected central government needed the support of the Green Party, which negotiated a deal for a pilot of congestion charging to be introduced. The governing Social-Democrats agreed, but debate would become heated. Much media coverage was negative, and Stockholm became politically divided on the issue. Supporters were sceptical of a pilot in case it failed (and would end the debate for many years). Ultimately it was decided that the pilot would be held and be followed by a referendum on whether it should continue to operate. All political parties pledged to respect the outcome of the referendum.

The pilot was a success, in that it significantly reduced congestion, improved bus service reliability and speeds, and did not result in negative impacts on retail businesses within the charged area. Notably when the pilot *ended* traffic levels returned almost to previous levels, demonstrating the value of congestion pricing even more clearly.

Polling before the pilot (in 2005) indicated 34% support for congestion pricing, but afterwards 53% (in late 2006). By December 2007, four months after pricing was reintroduced on a permanent basis, support was at 65%, with a poll in 2013 indicating 72% support for the "congestion tax".

The referendum narrowly passed[38] essentially resolving the debate over congestion pricing. Even though the referendum coincided with a change in government (towards the centre-right parties that opposed congestion pricing), the new government proceeded to re-introduce congestion pricing, but on the basis that net revenues would be used to help fund a major new motorway bypass from outer northern suburbs to the south. The use of funds to improve conditions for motorists, at least for the first few years, helped gain support for congestion pricing. Support was further increased, as central government was willing to offer additional funds to Stockholm, to support the introduction of congestion pricing, so not only were net revenues from pricing available, but additional contributions from government.

The transport packages that have been funded by the Stockholm congestion tax have varied over subsequent years and governments, with a move back towards more spending on public transport under centre-left/green oriented governments, with more spending on roads by centre-right/conservative oriented governments. The decision to earmark some revenue for road improvements helped to dissipate concerns that congestion pricing was an "anti-car, anti-motorist" measure, rather than a measure to improve conditions for motorists. Further support was obtained by noting the environmental benefits of pricing, in reducing emissions and improving local conditions within the charged area.

[38] The referendum was itself controversial as not all Stockholm local authority areas were included in the referendum, notably outer districts where opposition was strongest.

Gothenburg: There had been little discussion about road pricing in Gothenburg until after Stockholm implemented its congestion pricing scheme permanently. The granting of a substantial package of funding to Stockholm to support congestion pricing (with funds for rail and public transport improvements), generated interest in Gothenburg that it too could receive central government funds for major transport projects if it introduced congestion pricing. From the beginning, Gothenburg political support was for pricing as a tool of revenue collection, as noted elsewhere in this paper. This significantly undermined the ability to obtain public support as it was much easier to portray the proposals as a tax raising measure, rather than a traffic management tool. Discussion about the concept generated opposition during local government elections, with a political party elected to the city council in 2010 with the single policy of opposing road pricing (although not with a majority). A petition from 57,000 citizens triggered a non-binding referendum on the issue, which was held in September 2014. This saw a 57% vote in opposition, but this was largely ignored by the city government. The position of the city government being that the revenue is needed to fund infrastructure projects.

Opposition to pricing in Gothenburg by the public reflects several elements of the congestion tax scheme:

- It operates all day long, although congestion in Gothenburg is only concentrated in AM and PM peak periods;
- It applies to many locations that did not experience significant congestion;
- The largest portion of the transport package being funded by the net revenues are being used to help fund a major reconstruction of the city's intercity railway station from a terminal to a through station (which has little impact on most commuters, and as a result little impact on traffic in Gothenburg).

The total package of transport projects costs €3.4 billion, with €1.7 billion contributed by central government and €1.4 billion from the congestion tax (the remainder by contributions from local authorities), so local authorities were primarily interested in securing the central government funding with the congestion tax, even though they bore little of the direct tax burden themselves to pay for the package of projects. In summary, most of those paying the congestion tax receive little travel time savings compared to conditions before it was introduced, and those that pay do not support the spending predominantly on an expensive railway project of dubious economic merit.[39] With a much higher mode share for private cars than Stockholm, the difficulty in obtaining social licence in Gothenburg has been clear, but as the transport infrastructure package has proceeded, politicians have almost universally reverted to the argument that without the congestion tax, other taxes would have to be increased to pay for the already committed projects.

Although there is undoubtedly adequate social licence in both London and Stockholm for their urban road pricing schemes, this has not extended nationally, nor indeed in the case of London for expansion of the scope of the London Congestion Charge. The *economic* policy case for national road pricing in the UK was demonstrated in the Road Pricing Feasibility Study

[39] The Swedish National Audit Office noted the benefit/cost ratio for the project was only 0.45.

published by the Department for Transport in 2004[40], but it was considered that the implementation of urban road pricing schemes would help advance the public acceptability of national road pricing. However, the conditions for central London congestion charging were not replicated in other cities in the UK, let alone outside cities, and there was considerable opposition to national road pricing when it was proposed in 2005. Ultimately, the proposal was scrapped, alongside proposals for multiple urban road pricing schemes in other UK cities, primarily because of public concern of double-taxation (that road pricing would be on top of existing fuel tax and registration fees) and the use of the technology to monitor drivers. In Sweden, the Stockholm Congestion Tax was followed by study into the introduction of a national road user charging scheme for heavy vehicles.[41] This was ultimately scrapped due to opposition from residents and businesses in rural areas that feared that charging for road use by distance would penalise those in rural and more remote areas.

By contrast, Norway has most recently been piloting road user charging on a distance, time, location basis for light vehicles, as a possible replacement for its extensive network of toll roads, and the urban road pricing schemes discussed in this paper.[42] This is driven, in part, due to growing disenchantment with tolling and urban road pricing schemes across Norway.[43] The pilot was focused on testing road pricing based on distance, time and location to replace Trondheim's urban road pricing scheme, in part due to concerns as to its bluntness and the wider interest in charging electric vehicles for road use (to replace fuel tax, and tolls). Whether there is sufficient public and political support for such a change is yet to be seen, but it indicates that there is at least some pressure to replace local urban road pricing schemes with a consistent national approach, that streamlines charges for road use into a single platform and fee. For Tauranga, the implications if central government decides to reform nationally collected road user taxes (fuel excise duty and RUC) with technology that could enable congestion pricing to be implemented are likely to be positive in significantly reducing the costs of implementation. However, it seems likely that even if such a policy decision were made, that the transition period towards a ubiquitous system to enable road pricing to be implemented locally would take around five to ten years.

Key conclusions

While in many ways urban road pricing resembles other ITS projects and the introduction of tolls, it has several characteristics that mean implementation is more complex, and has issues that need addressing much more comprehensively than other such projects.

Critical are:

- Clear governance and accountability structures: The scale of revenue collection, and distribution means that conventional arrangements for other fees (e.g., tolls for individual roads, parking) may not be appropriate for urban road pricing. A single

[40] "Feasibility Study of Road Pricing in the UK: A Report to the Secretary of State for Transport", Department for Transport, 2004.
[41] ARENA study, discussed here https://trid.trb.org/view/863427.
[42] See this presentation, the pilot is called Geoflow https://uploads-ssl.webflow.com/5c487d8f7febe4125879c2d8/635fd7e52ce308adc8bed988_NW3%20Info%2021-10%20Roadpricing%20using%20geofences.pdf.
[43] See article on toll protests in Norway https://www.ft.com/content/2916df0a-cfa3-11e9-99a4-b5ded7a7fe3f

agency should be responsible for implementation, and be well incentivised to ensure pricing works efficiently, effectively, meets policy objectives and is flexible over time.

- Public acceptability: Urban road pricing is undoubtedly one of the most controversial and potentially divisive transport policy initiatives that can be implemented in a city. Design and consultation should seek to clearly communicate objectives and how pricing will help meet those objectives, and communicate in particular to those who will pay as to how it should benefit them. Ambiguity over communications (e.g., where and when pricing will be implemented), failure to communicate benefit to those who might pay and lack of clarity over the use of net revenues can all contribute to a lack of public support.

- Communications in advance of operation: Once a system has been procured, in the months approaching its commencement, it is critical to have a communications strategy to inform the public of the coming of pricing, when and where it will apply, how they should interact with the system (e.g., registering accounts or downloading an app) and who it will not apply to. This can save costs, frustration and inadvertent non-compliance when it comes to the system operating in the initial weeks.

Implementation of urban road pricing in Tauranga needs to also take into account the need for governance and institutional issues to be addressed for the city, around the delivery and operations of pricing, and the broader management of pricing in the context of the use of net revenues, and the impacts on tolls and other relevant charges. This is addressed in more detail in Section 1.9.

1.7 Impacts of Urban Road Pricing

This section discusses the impacts of congestion pricing on productivity, wellbeing and the distributional impacts of pricing (and how to address significant negative impacts).

Productivity

Productivity impacts are the direct and indirect impacts of the urban road pricing scheme on businesses, workers, and consumers. For businesses, the impacts are likely to be greatest for those that supply transport services (such as freight/logistics firms, bus operators, and taxi/on-demand transport services), followed by those highly dependent on transport (such as construction, property servicing, and waste management). However, many businesses reliant on logistics, such as retail and manufacturing are also significantly impacted by congestion, and conversely can benefit from improved trip reliability and reduced travel times that should arise from a well-designed and targeted urban road pricing scheme.

The effects of congestion on productivity for businesses can include:

- Labour and business operating costs to process late deliveries;
- Penalties or lost business revenue associated with missed schedules;
- Costs of spoilage for time-sensitive, perishable deliveries;
- Costs of maintaining greater inventory to cover the unreliability of deliveries; and
- Costs of reverting to less efficient production scheduling processes.

Trip reliability and travel time savings can deliver productivity benefits for businesses to minimise these negative impacts. Time savings through both increased trip reliability and decreased travel time enable more productive activity for vehicle occupants, which is directly more productive in some instances (such as freight operators and trade services). This includes simply being able to undertake more fee-paying work and scheduling more appointments during a given day because less time is wasted travelling. Furthermore, this productivity, in effectively lowering costs, may also increase competition in services businesses. This is because the threshold for commercial viability reduces as costs (such as travel time and fuel) reduce, and the geographic reach of such businesses can increase (as the same amount of travel time enables customers at a greater distance to access the services).

By enabling more production and more sales for the same or lower cost, their customers can also receive benefits and become more productive. These downstream effects can be considerable, but they are almost impossible to model efficiently. For workers and consumers it may mean more time for social, leisure and other discretionary activities, or to work longer hours (if there is flexibility in working hours). This can enhance wellbeing and deliver direct financial benefits.

These direct productivity benefits are further enhanced by the greater opportunities that reliable trips and reduced travel times present to businesses and employees. This includes:

- Access to more customers, as more customers can access the premises of a sales outlet, or more customers can be accessed for a service provider;

- Access to more employees, as a higher number of potential employees are willing to travel to the employment location;
- Public access to more employment opportunities, as more employers are accessible within the available travel time for potential employees (the reverse of the above); and
- Consumer access to more goods and services, lower travel times increases the opportunities to access retail, recreational, educational, and other services. This in turn increases competition for consumer goods and services, putting pressure in prices and service quality, which should enhance outcomes more generally.

Productivity benefits also arise from savings in transport investments that can be deferred, scale backed, or cancelled. Without road pricing, congestion would be more severe. This creates pressure for additional road capacity construction to be accelerated, whereas pricing capacity to spread demand would be a more efficient result. Similarly, the impact of congestion on the productivity of bus services is significant. One report from Wales indicated that a 13% decrease in bus speeds required a 26% increase in bus numbers and drivers to maintain a similar level of service.[44] In London, the introduction of congestion charging, along with incentives for bus operators on service quality, saw a 30% reduction in excess waiting time for buses after one year, with another 18% reduction in the following year. Although the proportion of this reduction attributed to road pricing is unclear, it is plausible that the significant initial travel time savings in the first year were a significant contributor to improved bus trip reliability.[45] Stockholm also reported significantly reduced travel times for bus services with reduced congestion, to the extent that some service frequencies were reduced. In short, urban road pricing has the potential to deliver higher frequencies of bus services at the same cost, or similar frequencies at lower cost.

Estimates of the productivity benefits from urban road pricing are difficult to find, primarily because most analysis considers only the direct user benefits. However, there is no shortage of estimates of the deadweight costs of congestion. It is notable that some research indicates the greatest benefits from road pricing may come from measures that prioritise trips of the greatest benefit. This is because pricing effectively prioritises trips at times of peak demand as to the value to the road user.[46]

Matthias Sweet's research of congested US cities indicated that average delays of more than 4.5 minutes per one-way trip, to specific locations, impeded job growth in those locations. The effect was:

you're either going to require higher wages to compensate you, or you're going to look for another job. And if congestion makes it harder to match the right workers to the best jobs, that's economically inefficient, too.[47]

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[44] "Source: Taming the traffic: The Impact of Congestion on Bus Services", Economy, Infrastructure and Skills Committee, National Assembly of Wales. https://senedd.wales/laid%20documents/cr-ld11145/cr-ld11145-e.pdf

[45] Source: "Central London Congestion Charging, Impacts monitoring Sixth Annual Report:, July 2008, Transport for London. p.94.

[46] "Traffic Congestion's Economic Impacts," Matthias Sweet , *Urban Studies* Vol. 51, No. 10 (AUGUST 2014).

[47] https://www.bloomberg.com/news/articles/2013-10-22/how-traffic-congestion-affects-economic-growth

These wider economic impacts are around access to labour markets, which benefits businesses (having more access to employees), benefits potential employees (with more opportunities), and increases the attractiveness of the location as a place for business. For Tauranga, this means it becomes a more attractive location because businesses in the metropolitan area become accessible to a wider geographic catchment of employees. This supports the location of a business due to proximity to potential customers and infrastructure to support the transport of goods, services, and customers further afield (specifically the port, airport, state highway connections to other regions and the East Coast Main Trunk Railway).

As more businesses choose to locate together in geographical proximity, there are also wider economic benefits from clustering. This reduces the transaction costs for trade between those businesses, but also contributes to the efficiency of the labour market.

The overall effect of efficient urban road pricing for Tauranga should lift the city's net productivity through the downstream effects of improved trip reliability and travel time savings. However, this improvement in productivity can only arise if pricing is applied at times and locations where congestion generates regular delays that are significant. The wider question is that what is "significant" depends on the trip type. Sweet's research indicates 4.5 minutes for a total trip may be applicable for commuter (and education) trips, but smaller delays may be higher for business and freight traffic making multiple trips during the day.

Wellbeing

More difficult to calculate is the impact urban road pricing may have on wellbeing. As with direct impacts, this is a balance between the impacts of the fee on people's personal budgets and the opportunity cost of the fee, against the value of the savings resulting from lower congestion and improved travel time reliability.

Generally, the enhanced wellbeing from efficient road pricing should come from:

- Trip reliability enabling more dependable planning of, and increased time for, family, leisure, and social activities around trips;
- Travel time savings enabling more time to be available for other purposes, thereby reducing stress in balancing time between work, travel, family, leisure, and social activities; and
- Reduced stress from easier travel conditions, whether by car or other modes.

These apply to private car users, bus users, and, to a lesser extent, active mode users (as they generally can bypass congestion, although may be affected by delays at traffic signals). In Singapore, attitudinal surveys after the introduction of road pricing indicated that bus drivers, cyclists, and residents within locations subjected to pricing saw the effects of pricing as positive for them. Whereas car users, taxi users, and residents of areas outside priced areas saw it as neutral or mildly negative. This appears to reflect how much people pay under the pricing system relative to the benefits they experience from decreased congestion.

Care must be taken around scheme design, as wellbeing for private car occupants is unlikely to be enhanced if road pricing is applied in locations at times where congestion is insufficient to justify pricing. In other words, if the price paid at less congested times is noticeably higher than the value of travel time savings and reliability benefits, then there is a net loss to the consumer.

As noted above, there are longer-term benefits to wellbeing that reduced travel times present in terms of opportunities for the public, whether as workers or consumers. These may be seen as more subjective and complex to assess, as they reflect the willingness to travel as a function of time.

Although people vary in what they regard as "acceptable" travel time to access different opportunities or services, everyone has a time "budget" that they may decide to "spend" in different ways. Accessing a better job may be offset by a commute that is significantly longer, as is accessing a retail outlet with cheaper goods or a wider range. One of the key benefits of living in or close to a growing city is that opportunities for employment, education, recreation and consumption of goods and services are greater than in smaller cities, towns, or rural areas. Traffic congestion inhibits access to these opportunities, by placing penalties on time that are lower or non-existent in other locations. This effectively deters residents from travelling beyond a certain threshold to access an opportunity. Similarly, service providers (such as plumbers, cleaners, and food delivery services) frequently limit the range of their customers based on travel times, which restricts their customer numbers, and access to their services for consumers. This reduces competition and increases prices for consumers. Urban road pricing could therefore increase the available service providers for consumers, thereby incentivising price decreases and service quality increases. This will have a net benefit to overall wellbeing, regardless of whether consumers pay to use the roads at peak times or not.

This could be depicted by considering the opportunities available by travel time and mode from key population centres, according to the proportion of potential employees willing to commute for certain times. In large metropolitan areas like Auckland there is willingness to commute for longer periods, reflecting the cost of housing and in some cases salary levels for certain types of jobs. In Tauranga this is likely to be less prevalent, but will grow as the city increases in population and scale.

Travel times present a barrier to opportunities for employment, education, recreation, retail, and services (including service providers at home). Urban road pricing that improves trip reliability and reduces travel times should not only increase the number of jobs available for residents of locations affected by congestion, but also increase access to education, recreation, social, and cultural opportunities.

Finally, although it may be considered an element of productivity, the effects of congestion on the access to and performance of emergency services is often ignored. One estimate from California is that traffic congestion imposes costs of USD $130–360 million (NZD $208–507 million) per annum due to delays to fire and ambulance services.[48] These costs range from additional property damage through to loss of life. Whilst these costs for Tauranga are likely to be significantly smaller, there will be similar costs arising from the effects of congestion on emergency vehicles, particularly during time critical emergencies. Addressing such congestion is likely to have a positive impact on wellbeing overall.

Effect on overall affordability of travel

The affordability of travel is a function of both price and time. Although there is understandably a primary focus on price when analysing urban road pricing, it is important to

[48] "Traffic Congestion and the Performance of First Responders: Evidence from California Fire Departments" Louis-Philippe Beland, Daniel Brent, *Louisiana State University*, May 2018

not underestimate the importance of time. For all journeys taken in an urban area, there are trade-offs around the costs of travel:

- Driving costs, such as tolls and fuel.
- Public transport fares.
- Parking costs.
- Parking availability, the scarcity of which affects time.
- Travel time, including walking time between parking and public transport.
- Reliability of expected travel time.
- Waiting time for public transport and parking, if scarce.
- Reliability of waiting time for public transport and parking.
- Comfort of travel in vehicle, at waiting locations, on topography of route and in urban environments.
- Effects of weather, especially on active modes and public transport.

These are also influenced by the purpose of travel:

- Importance of travel time reliability (e.g., commuting, education, business, or other appointments).
- Flexibility of travel time (e.g., comparing commuting, social, retail, and recreational trips).
- Transporting children or goods (e.g., retail purchases, refuse, sports gear).

Key to evaluating the impacts of urban road pricing on the affordability of travel will be the trade-off between the cost of the fees of urban road pricing and the value placed on the resulting time savings both to fee payers and those beyond the charged network. For example, in Stockholm, many of the travel time savings were upstream and downstream of the central city cordon. This is because motorists using roads approaching the charging points whose journeys terminated outside of the cordon still benefited from reduced congestion on their journeys.

Many journeys are not undertaken because the travel time is excessive. (e.g., people decide whether they will travel to an event, a shop, or a place based on how long it will take to travel there and back, compared to alternative uses of time). The price of travel is also part of the equation. For driving, there is a sense of the cost of fuel and parking, although for short trips there is little concern for the former unless someone is rationing travel due to a low income. The effect of urban road pricing to address congestion should be to reduce the time penalty at peak times in exchange for the financial penalty of using road space at a time of peak demand. The reasoning being that enough motorists have options to change travel time, travel mode, or to not travel at all on that occasion, which removes enough car trips such that others benefit from reduced congestion. *Table* 5 summarises how urban road pricing can change various factors of travel affordability.

Factors of travel affordability	Urban road pricing potential impacts
Driving costs	High (increasing direct costs)
Public transport fares	None (unless net revenues used to reduce fares)
Parking costs	None (indirectly may lower if demand reduced)
Parking availability	None (indirectly may improve if demand reduced)
Travel time	High (reducing travel times for driving/buses)
Reliability of travel time	High (improving trip reliability for driving/buses)
Waiting time	None
Reliability of waiting time	Medium (improving trip reliability for buses)
Comfort of travel	Medium (eases driving stress, reduces traffic for active travel)
Effects of weather	None

Table 5 Potential impacts of urban road pricing on travel affordability

To positively affect affordability, an urban road pricing system must offset increases in driving costs with decreases in the cost of travel time (including travel time reliability), both for driving and alternatives to driving, and use net revenues appropriately.

Evidence from Gothenburg indicates that applying urban road pricing outside periods and locations of congestion can have a net negative impact on the affordability of travel. This is because travel time savings overall do not offset the cost of the fees charged. Figure 13 shows that even the highest income drivers, which have the highest value of time, are not net beneficiaries from the travel time savings of the Gothenburg congestion tax. This is because the scheme operates between peak periods and charges multiple locations which do not experience significant congestion at *any* time of day.

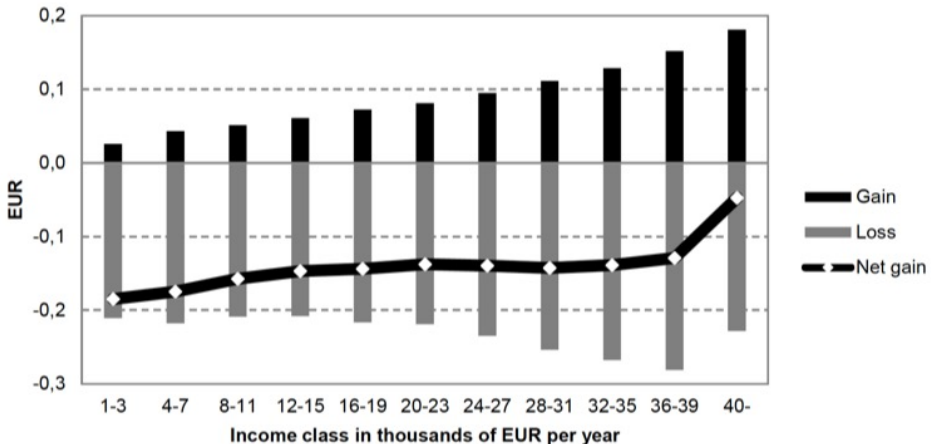

Figure 13 Net losses for car drivers by income group residing in Gothenburg labour market area[49]

This not only affects travel affordability for commuters, but also for educational, recreational, and retail trips, as the Gothenburg congestion tax is designed to raise revenue, not deliver net benefits in terms of reduced congestion.

A scheme designed to relieve congestion, such as in Stockholm or Singapore, sees affordability impacts varying. Outside of charged periods, there is no effective impact on affordability. This does not include any impacts from the use of net pricing revenue to improve transport

[49] Source: "*The Gothenburg Congestion charges: CBA and equity*" Jens West, Maria Börjesson, Centre for Transport Studies, Stockholm, Working Paper 2016:17

infrastructure. During charged periods, discretionary trips with more travel time flexibility should be less affordable (e.g., for recreational or retail purposes), but impacts for commuter, business and educational trips should be neutral. Impacts should be positive for users of non-car modes, as they should experience lower congestion without paying fees, even excluding the impacts of using any net revenues to enhance such modes. For car-users the impacts on affordability are likely to range from negative to neutral, depending on their value of time and the cost of changing behaviour.

A key factor is the use of net revenues. In Gothenburg a key criticism is not only that the scheme charges car users at times and locations where there was little previous congestion, but that most of the net revenues are used on projects that generate few benefits for those using cars or public transport. In some cases, these projects even have benefit-cost ratios of less than 1. The redesign of the central railway station for intercity passenger trains primarily benefits intercity trips primarily by visitors and those from outside Gothenburg, not local trips. This means that the Gothenburg congestion tax reduced affordability of travel for those commuting in Gothenburg, in net terms. By contrast, if net revenues are used to support funding of transport projects that benefit trips affected by the urban road pricing scheme, this can offset the impacts on the affordability of travel. In the case of Stockholm and the Norwegian urban schemes, this has included major highway projects that reduce travel times, and enhancements to commuter public transport. Another way to enhance affordability is to recycle net revenues through reductions in other fees and charges. In the Tauranga context, this could come from reducing rates, parking fees, or public transport fares. This could also come from providing credits redeemable either as cash or to use for services such as parking or public transport.

The key issue is managing the distributional impacts of urban road pricing, such that those who may face challenges in affording urban road pricing fees to access employment or essential services are not unduly disadvantaged.

Distributional impacts and solutions to such issues

Distributional impacts (sometimes referred to as “equity”) relate to whether a policy intervention applies fairly to those targeted, and how it impacts them according to their ability to pay or ability to reasonably change behaviour to avoid paying. In the context of urban road pricing this reflects two key issues:

- Charging vehicles according to the relative use of the network.
- The effect of road pricing on those on lower incomes, especially those with little flexibility to change behaviour regarding high value trips.

The first point is reflective of how an urban road pricing rate structure might apply to different types of vehicles. For example, Singapore sets rates based on the “passenger car unit” equivalent of road space occupancy. This means charging motorcycles half price of cars and charging heavy vehicles two or three times the rate of light vehicles. If urban road pricing is intended to be a charge for occupancy of a scarce resource, then this is a reasonable approach. Stockholm, Gothenburg, and London all charge the same rate regardless of vehicle size (although in London motorcycles are exempt), in part to recognise that mode shift by heavy vehicle users is extremely unlikely and that time-of-day changes are unlikely to be influenced by urban road pricing rates. The question of how to set urban road pricing charges by vehicle type should be considered as part of detailed design.

The effects of urban road pricing on more vulnerable communities are a mix of four elements: income, geography, trip purpose, and flexibility to minimise or avoid road pricing.

Traditionally, concerns about distributional impacts of those on lower incomes have been focused on values of time, based on incomes, as a reflection of how much an individual earns during employment. This is coarsely seen as a proxy for value of time such that, for example, someone on an income of $150,000 a year has a higher value of time than someone on $30,000 a year. This is then seen as meaning that a travel time saving is more valuable to someone on a higher income than someone who is not.

Early experience of toll lane users in the United States indicates that for some on lower incomes, with multiple jobs, the value of time is dependent on the specific trip type. The cost of missing an appointment or a flight may be significantly greater to those on lower incomes with less flexibility than those on higher incomes.

However, in general terms those with higher values of time benefit the most from an urban road pricing scheme because they are willing to pay the fee to use the road that is less congested. In short, they value travelling at that time and the travel time savings. Those who do not perceive such a value choose not to pay the fee, and travel at a different time, by a different mode, or to not travel at all. This is key to the effects of urban road pricing in managing demand.

The impacts of this depend on several factors, such as:

- Purpose of travel;
- Flexibility of travel time;
- Accessibility of alternative modes and their costs relative to driving; and
- The effect of the fee on disposable incomes.

At peak times of travel, business, commuting, and educational trips may be deemed as having the highest value. Business trips, because they are directly related to productivity and generation of income for the business, its shareholders, and employees. Commuting, because it provides access of employees to employment and employers to employees. Educational trips, because they provide access to education. The most vulnerable groups out of these are those on lower incomes, either accessing employment or education, who cannot access these outside of the operating hours of a peak period pricing scheme, and do not have access to cheaper alternative modes in terms of travel and waiting time.

Given this, urban road pricing schemes designed to reduce congestion seek to encourage behaviour change for two broad categories of trips:

- discretionary trips that need not be undertaken at the times of peak demand; and
- essential trips that can shift modes or vary time of travel moderately to spread demand.

It is widely accepted that discretionary trips, regardless of the demographic of those affected, should ideally be consolidated and/or be undertaken at off-peak times, so that road capacity at peak times is primarily available for essential trips, including commercial vehicles and freight. Trips for social, recreational, and retail purposes are almost always not time-bound,

and urban road pricing should encourage such trips to be made at other times or by other modes.

Essential trips might be considered those to access employment, education, or essential services such as healthcare. Those on lower incomes tend to have less flexibility about employment times and locations. Furthermore, choices around times for education and healthcare are also likely to be largely determined by the institutions supplying those services. Urban road pricing should ideally not unduly impact those users, unless there are modal alternatives that do not penalise total travel time (including waiting time) and the cost of travel as much or more than driving. Otherwise urban road pricing may have negative distributional impacts. In short, there is a risk that urban road pricing could exacerbate socio-economic gaps for those located where their commute or trips to education or health services face higher costs of travel.

Development of the (subsequently cancelled) Manchester congestion charging scheme saw development of a proposed "low-income worker discount" of 20% off the congestion charge fee. This was proposed to function for a temporary period of between three to five years, and to provide a transition, by reducing the fee by enough so that workers on low incomes would be no worse off after accounting for travel time savings. Functionally it was proposed that employers would register workers in the scheme with a vehicle to undertake one return trip each weekday with a discount. The discount was proposed to be phased out after several years, reflecting the mobility of many low-income workers to relocate both employment and housing, but also expected improvements and changes in public transport service patterns to provide adequate alternatives.

Standard transport-economic theory indicates that the fees collected should be used to benefit those who pay, but according to Eliasson, this doesn't consider three important factors:[50]

- First: network effects. Since queues propagate "upstream", even those not going through the actual bottleneck will suffer from queues. Pricing traffic in the bottleneck to reduce queues, all upstream traffic will benefit – not only drivers paying the charge.
- Second: the effect on the urban environment. Typically, standard analysis of congestion charges takes no account of effects for pedestrians or cyclists, or the effect on the perceived urban environment.
- Third: the self-selection effect on trips and on the value of time. Congestion charges will tend to "sort" trips such that trips with high value will stay on the road (and enjoy time benefits), while low-valued ones will be priced off. Not taking this phenomenon into account will underestimate the value of the time benefits.

He notes that individuals belong to different "groups" on different days, not by income type, but trip purpose. The reason being that travel patterns are much more variable than most realise. In Stockholm, on any given day only 5% of car trips are affected by the charges, which notably operate all day from morning peak until the end of the evening peak. However, over two weeks around 43% of private cars registered in greater Stockholm will be subject to at

[50] Source: The Stockholm congestion charges: an overview, J. Eliasson, Centre for Transport Studies, Stockholm, CTS Working Paper 2014:7, p. 37.

least one charge, but only 2% of cars pay twice per weekday (as in a regular commuter). Although the conditions in Stockholm are different from Tauranga, as the public transport mode share is substantially higher, it is unlikely that trip patterns are more homogenous. Whilst a much higher proportion of employees commute by car in Tauranga than in Stockholm, the bigger question is what proportion of those vehicles would be subject to an urban road pricing fee, and how frequently they would be.

In Gothenburg, the use of net revenues is critical in evaluating the distributional impacts of its congestion tax, particularly as the net travel time savings are lower than the value of the fees collected from road users. It was noted that:

In Gothenburg the revenues are not spent to improve the local public transport system to benefit local groups. It is rather spent on a rail tunnel that will mainly benefit commuters further out in the region as explained in Section 2. As long as a congestion charge is justified from the perspective of economic efficiency and to price externalities, negative distribution effects may be less controversial. But since the congestion charge in Gothenburg is mainly implemented for fiscal reasons, to finance the rail tunnel and other infrastructure projects, the equity concern may be more problematic.[51]

Distributional impacts should be assessed in parallel with the detailed economic appraisal of the project. This should seek to identify:

- Trips that incur the most road pricing fees, ideally by trip purpose, demographic, time of day and origin/destination pairs; and
- Trips experiencing the greatest benefit, by similar factors.

This would then identify those who gain the most and lose the most from urban road pricing, excluding the impacts of how net revenues may be distributed. This would help to inform how best to use net revenues to mitigate negative distributional impacts.

Options to address negative distributional impacts and locations with high levels of car dependency

Negative distributional impacts, including impacts on locations with high levels of car dependency can be addressed through measures that affect:

- Urban road pricing scheme design.
- Conditional access rules for locations.
- Use of discounts, exemptions, or caps for user groups.
- Improvements to alternatives.
- Phased introduction of charging points, to progressively test impacts, rather than a “big bang” that could be seen as disruptive.
- Partial redistribution of revenues from residents in affected locations.

[51] Source: The Stockholm congestion charges: an overview, J. Eliasson, Centre for Transport Studies, Stockholm, CTS Working Paper 2014:7.

Scheme design: Urban road pricing schemes that target peak demand and congestion only where and when it occurs are likely to minimise negative distributional impacts. Evidence from Gothenburg suggests that if that scheme were focused only on routes with serious congestion at peak times, then the negative distributional impacts of that scheme would have been greatly reduced. Singapore's experience demonstrates how it is possible to have charging points with prices that vary by location and times of operation, which enables pricing to be highly refined. By minimising the risk of pricing trips on uncongested routes, the negative impacts of a scheme can be minimised by design.

Conditional access rules: The geographic nature of a road network sometimes means it is difficult to avoid placing charging points on a road which might unduly impact some trips from a specific location with few alternatives. Such examples have existed in Stockholm (Lidingo Island) and Gothenburg (Backa). In Stockholm, trips from Lidingo Island crossing a charging point were exempt, if they exited another charging point within a set period. This exemption was removed once Lidingo was connected to a new bypass highway which made it possible to enter and exit Lidingo away from the cordon. In Gothenburg, residents of the suburb of Backa were unduly affected by the city's congestion tax, which operates from 0600 to 1830 on weekdays, when making short trips across the E6 highway to the eastern part of the suburb by the river. This included a wide range of trips, such as healthcare, retail, social, recreational and access to other services. Given these impacts, Gothenburg introduced in 2020 a conditional exemption so that any vehicles passing charging points 17-21 will pay only if they have passed a control point to the west, which means the trip is a through trip. This is depicted in Figure 14.

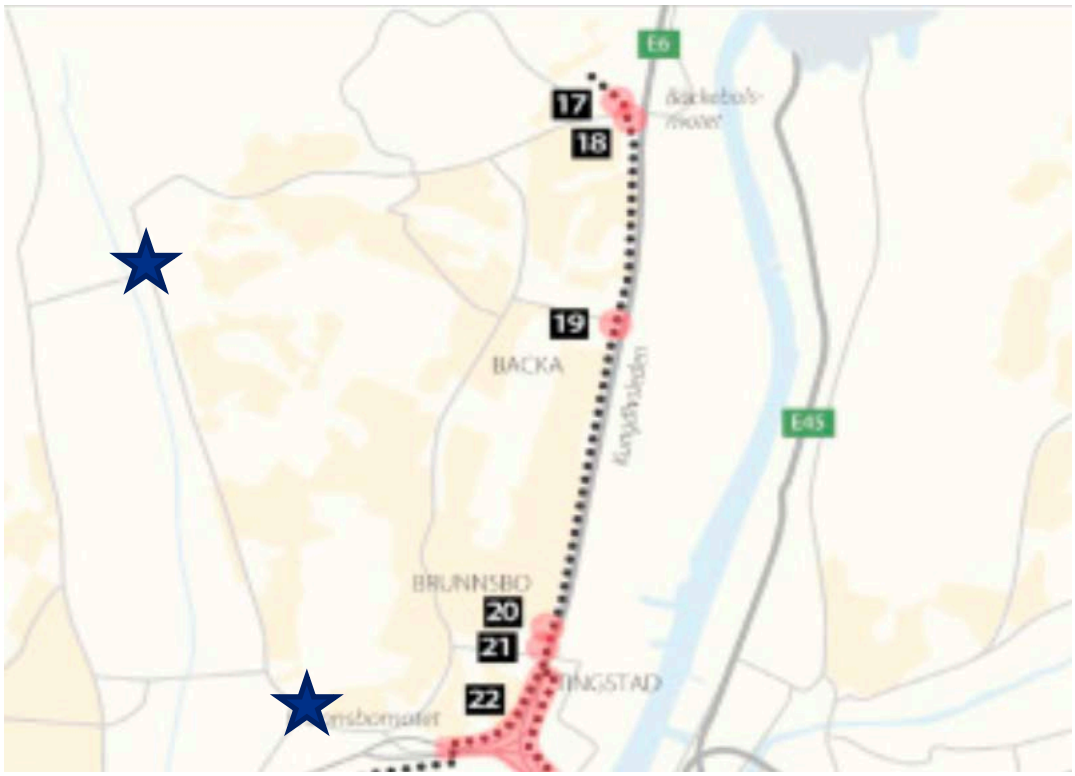

Figure 14 Backa exemption in Gothenburg

Such a conditional access system can be implemented for any local area where use of the charged route is necessary to access essential services. It is important to note that Backa residents using any other parts of the network subject to the congestion tax are still required

to pay, but they are protected from being unduly affected when undertaking local trips to essential facilities.

Discounts, exemptions, or caps: Discounts or exemptions can be used to mitigate negative impacts. For example, a single return trip per day could be granted free of charge or at a substantial discount for residents with vehicles registered in a specific location that has limited alternatives. Employers, educational institutions, or health providers could be permitted to register staff, students, or clients under specific criteria (such as income or Community Services Card eligibility) for a discount over a transitional period if there are issues in accessing employment or essential services. Caps may be applied generally (limiting the number of times a specific vehicle can be charged during a day) or specifically (to vehicles owned by specific users), to limit impacts. However, this may also disincentivise more efficient vehicle use by commercial users. Care needs to be taken not to apply discounts too widely, or to define them too loosely, to avoid the risk of fraud and administrative costs from such programmes.

Improvements to alternatives: Provision of improved public transport and/or active transport options (whether to support public transport or not) can mitigate negative impacts, particularly if an urban road pricing scheme affects a specific geographic location. For public transport, focusing on peak services to key locations or to feed onto existing services may also be an opportunity to enhance access more generally for an area.

Phased introduction of pricing: A key characteristic of urban road pricing is that the impacts of charging any single point can be significant well beyond the immediate corridor. The downstream and upstream impacts can ease congestion at other points along the corridor, which may *reduce* the urgency to implement additional charging points on the corridor. This should mitigate some negative impacts without unduly undermining the effectiveness of the scheme for reducing congestion. The Congestion Question noted that there are merits in (Auckland) implementing charging on the city centre first, to identify the impacts on the major corridors approaching the city centre, before implementing corridor charges at other locations in the Isthmus and beyond. Implementing locations that may minimise negative impacts, but have significant positive impacts, first may delay or avoid adding charging points at locations where there may need to be further interventions to avoid negative impacts.

Partial redistribution of revenues to people from affected locations: A more radical, but direct, response to concerns around distributional impacts in areas with high levels of car dependency would be to redistribute net revenues, equivalent to revenue generated from such locations. This could be done through direct transfers (credits to residents) or in public projects that directly benefit the residents of such areas. Such credits could be made several times a year or be more indirect and support progressively reducing car dependency when and where it may be efficient to do so.

1.8 Modelling of operational urban road pricing schemes

There is extensive experience internationally of modelling proposed urban road pricing schemes, but the experience of modelling in advance of an operational scheme is significantly more limited. This section reviews the experience of the four most notable and sophisticated of such schemes (Singapore, London, Stockholm, and Gothenburg) in modelling results before and after the introduction of their respective schemes.

Singapore

As it dated from 1975, there was limited modelling available to develop Singapore's original ALS scheme, but rather economic estimates made of the impacts of pricing on demand for what was defined as a practical scheme at the time. Prices were derived based on an assessment of elasticity comparing responses to parking prices, as to how they might reduce demand at peak times sufficiently to relieve congestion. The estimates were below the actual demand response, and the demand elasticities identified were used in assessing expansion of the operating hours and geography of the scheme. Experience of the demand responses from the ALS and its successor (the RPS or Road Pricing Scheme) were used to assess the rate structure for the Electronic Road Pricing (ERP) scheme before 1998, to develop pricing to achieve targeted levels of service for the priced corridors. As Singapore was willing to take an iterative approach to urban road pricing over time, it adjusted charge rates by time and location as it expanded the ERP scheme, with its quarterly analysis of traffic flow and speeds used to inform changes to the scheme. This example presents limited guidance on modelling and appraising the Tauranga scheme. The key lesson that may be derived from Singapore is the value of gradualism in introducing pricing, because it enables future stages to be implemented guided by the behavioural responses seen with the first stage of implementation.

London

By contrast with Singapore, extensive modelling and appraisal had been carried out on options for urban road pricing in London over many years.

The ROCOL study which formed the basis for the final London congestion charge scheme used Transport for London's (TfL) strategic transport model to forecast demand impacts by mode and origin/destination by zone and applied these results to multiple local traffic assignment models to identify the effects on traffic flow at and approaching the charging zone. Although the overall impact was to reduce demand for road space by vehicles subject to the charge, significantly increased congestion was identified by the traffic assignment models at various locations. This resulted in a study that identified ways to mitigate those impacts through redesigning intersections, changes to traffic signal phasing and other traffic rules. Such impacts were primarily around the boundary route to the congestion charge area, which reflects traffic seeking to avoid paying the charge if its final destination is not within the area. The study was followed up by development of the final scheme design and selection of the proposed fee rate (at the time, £5) which was then applied to the strategic transport model, with the final scheme design to develop the forecast impacts. Those impacts were forecast to be a 10-15% reduction in traffic with a 20-30% reduction in delays, actual impacts were a 15% reduction in traffic with 30% reduction in delays (measured by the proportion of time vehicles are stationary or moving very slowly in queues). This suggested that the modelling approach taken was appropriate for the introduction of the scheme.

Post implementation, TfL collated detailed counts of traffic at all entry points and statistics on public transport usage. Over the subsequent five years, TfL used moving vehicle observer surveys, monitoring and enforcement cameras, trip diaries, travel surveys, data from parking providers, business surveys, environmental indicator assessment and economic case studies on specific sectors and locations to undertake annual impact monitoring reports. These reports provided data on changes in transport, economic, social and environmental policy indicators, and what could and could not be attributable to the congestion charge. Noting it is sometimes difficult to distinguish between the scheme impacts and wider economic or policy impacts (such as significant increases in bus services).

Stockholm and Gothenburg

The two examples in Sweden are two different cities that took similar approaches to appraising and modelling in advance of their respective road pricing proposals. Gothenburg with a population of only around 500,000, but with a mode share for public transport of 26% for trips passing locations that would be priced (compared to 77% for Stockholm).

Overall approach

For Stockholm and Gothenburg, the Swedish national demand forecasting model was used (called SAMPERS). It is described as follows:

Sampers consists of nested logit models for six trip purposes (Work, School, Business, Recreation, Social and Others), modelling choices of trip frequency, destination and mode (car as driver, car as passenger, public transport, walk and cycle). The demand models include private and business travel. Freight traffic OD matrixes are fixed (and thus assumed to be insensitive to congestion charge). There are three analysed time periods (morning peak, evening peak and off peak), over which demand is distributed using fixed time period factors per trip purpose applied uniformly to all origin-destination pairs. Road and transit link flows are calculated using the software package EMME/3.[52]

In Stockholm the traffic reduction effect was 20% and in Gothenburg 12%, both within the range of what modelling forecast. Price elasticities forecast and observed were similar at -0.87 in Stockholm and -0.69 in Gothenburg, but when split between peak and off peak, the elasticity in the off-peak was 1.7 times higher than the peak elasticity in both cities (-1.13/-0.67 and -0.93/-0.53 respectively). This indicates how much more price sensitive off peak trips are to pricing, primarily because they include a much higher proportion of discretionary trips compared to the peaks, but also because in both cases, the pricing proposals included pricing in both directions, so that an inbound trip in the off-peak period may also face paying for an outbound trip during the peak.

In Stockholm it appears that elasticities are increasing over time (from an average of -0.87 to -1.24 in 2014), which is attributed to the gradual growth in adaptation to the congestion tax (supported by enhanced public transport), but also the gradual increase in travel times for driving in Stockholm due to construction work. In short, people in Stockholm are becoming more responsive to the congestion tax, not less, although this responsiveness is growing for motorists that are not regular users of the congestion tax (but reducing for those that are).

[52] Source: "The Gothenburg congestion charge Effects, design and politics", Maria Börjesson, Ida Kristoffersson, CTS Working Paper 2014:25, Centre for Transport Studies, Stockholm.

In Gothenburg, the opposite trend has been noticed with a gradual reduction in elasticity (from -0.69 to -0.52 in 2015). This has been attributed to the lower level of public transport service and more dispersed employment patterns in Gothenburg, meaning that drivers over time "accept" the presence of the congestion tax and respond less to it. Gothenburg's level of public transport service is significantly higher than that in Tauranga, suggesting that Tauranga would have even lower demand elasticity over time, unless its growth results in transformative changes in modal use in the coming decades.

Sensitivity to the congestion tax in itself does not automatically apply to sensitivity to the increases in the charges, for those already paying them. In both cities there was a much more muted demand response than was forecast. In Stockholm, the congestion tax at peak time was increased by 75% in Gothenburg by 22%. The effect was only a 5% reduction in trips across charging points in Stockholm, and a 1% reduction in Gothenburg, suggesting elasticities of only -0.28 and -0.16 respectively for both cities. This is explained as having already priced off most discretionary trips, the initial demand response to both cities' road pricing schemes resulted in remaining users having a high value of time. Most price sensitive users have already changed travel time, mode or no longer travel so frequently, so those remaining are still willing to pay to drive. Another factor is that once urban road pricing is applied, the "zero-priced goods effect" is gone, in that decisions regarding demand for what are perceived as free goods (like road space) change once a price is applied.

For Tauranga, what this means is that the modelling of the effects of increases in pricing on an existing scheme needs to take into account the declining demand elasticities after a scheme has been in place. The greatest "return" from urban road pricing, in demand management terms, in the application of a price to a location at a specific time, in the first instance. Increasing that price will see diminishing returns in reducing demand, because the proportion of drivers with price sensitivity and discretion to not drive at that location and time reduces significantly.

Impacts

Demand stabilised in Stockholm after one month of operation, but in Gothenburg it took eight months. Gothenburg overpredicted traffic reductions in the peak, but not the off peak. *Table 6* depicts the difference in observed and actual demand after one year of scheme operation in Gothenburg.

October 2012 to October 2013	Observed	Forecast
AM Peak	-13%	-18%
PM Peak	-12%	-18%
Mid-day	-12%	-13%
Charged hours	-12%	-15%
Uncharged hours	-2%	0%

Table 6 Modelled and actual changes in trips across cordon in Gothenburg

This is not the outcome from modelling for Stockholm, where the prediction of peak traffic decline matched the outcomes, but interpeak decline was underpredicted because it did not expect sufficient of a response on discretionary trips. Note both schemes apply during interpeak hours, and it proved difficult to identify the proportion of trips that shifted from

peak to interpeak vs. those that shifted mode or did not travel at all during the interpeak period (primarily because surveys of road users saw few that could recall what their previous trip patterns were). Actual traffic counts only present raw figures, so whilst peak travel traffic counts indicate a reduction in vehicle trips (suggesting some shifted mode, some shifted travel time and some trips consolidated), interpeak traffic counts will include some that shifted from the more expensive peak period, along with a reduction from those that shifted mode, consolidated trips and a few that would have shifted travel time beyond the peak/interpeak charging period. However, it is very difficult to distinguish the proportions that made these different types of behavioural responses.

The modelling of route choice behaviour over-predicted changes in route choice than that which was observed in practice. This was particularly so in Gothenburg, even though it has more opportunities to avoid charged locations than Stockholm (which was just a simple cordon). *Table 7* illustrates how the modelling in almost all cases in Gothenburg overestimated the likely changes in traffic volumes due to pricing in the AM peak at uncharged locations on the network. With only one exception, this suggests that drivers would rather continue to drive on major routes and pay a fee, than to add travel time (and uncertainty, and the discomfort of a less direct route) to avoid paying the fee.

Location	Forecast AM peak traffic change	Actual AM peak traffic change
Sœderleden	+3%	+1%
Bergsjøvågen	+15%	+3%
Bjørlandavågen	-8%	-4%
Angeredsbron	+18%	+4%
Jordfallsbron	0%	+24%
Landvettervågen	+32%	+19%
Tuvevågen	+22%	+6%
Norrleden	+34%	+26%

Table 7 Gothenburg uncharged location forecast and actual change in trips

Conclusion

The standard approach to model and appraise the transport economic benefits of an urban road pricing scheme, by using the outputs of a strategic demand model to apply to a trip assignment model on the network, appears to remain valid and deliver adequately accurate results in forecasting the effects of an urban road pricing scheme on demand and revenues.

However, experience in Sweden seems to indicate that there is a risk that models will over-estimate the willingness of drivers to divert around a charging point, to save money, but underestimate the responsiveness of drivers undertaking discretionary (non-commute, non-education, non-business) trips. Data on the proportions of car traffic by trip purposes would likely be highly informative in helping to establish the likely elasticities of demand for applying urban road pricing to various locations in Tauranga. Given Tauranga is a highly car-dependent city, this is likely to mean a relatively lower level of demand elasticity to pricing than in the cities that have implemented urban road pricing to date. This is due to the lack of alternatives to driving for many trips. What will be important is ensuring that the modelling for Tauranga assigns appropriate factors to roads beyond travel costs, to reflect the likelihood of diversion responses to charges on main routes. The existing toll roads in Tauranga provide a useful baseline for this, but there is likely to be a difference in response between introducing pricing on an existing road, with an obviously inferior alternative that has rarely been used.

However, unlike London and the cities in both Sweden and Norway that have implemented road pricing, if pricing is only applied in the peaks, the option to change trip time is likely to see higher elasticities of demand for travel in those times, at least as an initial demand respond sees discretionary trips priced out of those periods at those locations.

1.9 Latest developments

Singapore

As a pioneer of urban road pricing, Singapore has long been recognised as operating the most sophisticated congestion focused urban road pricing scheme of any city. Each priced location has its own rates by time of day increments, direction of travel and vehicle classes, and is subject to quarterly reviews of pricing to reflect network performance at that location.

Urban road pricing in Singapore has evolved in three major stages so far:

- 1975: Introduction of paper-based permits for access to central city cordon during the morning peak, later expanded to evening peak and interpeak periods (called the Area Licensing Scheme)
- 1995: Introduction of permits for access to three expressways during weekdays (called the Road Pricing Scheme)
- 1997: Introduction of electronic road pricing (ERP) for the cordon and expressways, with progressive expansion to a second cordon and multiple expressways and arterial routes.

In the past five years Singapore has been developing its replacement system called ERP 2.0. The existing system is paid on two-way in-vehicle on-board units (OBUs) that enable large overhead gantries to detect vehicles, and deduct value off of prepaid smartcards inserted into the OBUs. This is to be replaced with GNSS OBUs (see Figure 15) that measure road use by correlating location via satellite-navigation signals to an on-board map. These OBUs have some parallels to those used in New Zealand for electronic road user charge (eRUC) collection but are supplemented by a graphic user interface (GUI) screen, to display traffic, parking and other transport mode information, along with pricing information to drivers. It is important to note that Singapore does not intend to charge by distance, although ERP 2.0 will have the capability of measuring and reporting distance travelled (and could be used for distance based charging).

The reasons for introducing ERP 2.0 are as follow:

- The existing ERP system is at the end of its economic life;
- Existing ERP gantries at charging points (Figure 16) can be replaced, in favour of less visually intrusive pole mounted ANPR cameras for enforcement;
- More information can be supplied to drivers, including live traffic and parking data, and parking payment can be automated;
- More flexibility in introducing new priced points anywhere on the road network, enabling it to be more responsive;
- Potential for distance based pricing at a later date.

Figure 15 Illustrative new Singapore ERP OBU

Figure 16 Singapore ERP gantry

All vehicles in Singapore are to have new OBUs installed to replace existing units, at no cost to owners. As of August 2022, computer chip shortages and logistical issues with delivery have delayed roll out of the new system until the second half of 2023.

Once it is introduced, it will the world's first urban road pricing scheme operating using GNSS technology and will demonstrate the technical and financial viability of introducing such technology onto a fleet of vehicles. As a city state, it is relatively easy to make such technology mandatory on vehicles, but for Tauranga this is unlikely to be viable, unless central

government mandated such systems on all vehicles across the country to support wider pricing initiatives.

Brussels, Belgium

The Brussels City Region Government has been considering the merits of introducing urban road pricing across its jurisdiction with a network pricing scheme (applying to all public roads). The project called "Smartmove" proposes replacing annual vehicle registration and licensing fees with a distance-based fee, with higher peak charges.[53] Although it would replace fees for Brussels vehicles owners, the fee would apply to all vehicles entering Brussels. Annual vehicle licensing fees in Brussels currently range from around NZ$135 to NZ$4,200, depending on emissions rating and engine capacity.

The objectives of *Smartmove* are to:

- Reduce congestion (target of 30% reduction in time lost in congestion);
- Reduce emissions (target of 10% reduction in CO_2 emissions); and
- Generate new revenue to invest in infrastructure.

A stated metric is to reduce private car trips by 30% and VKT by 18% by 2030 by encouraging mode shift. Smartmove includes not just road pricing, but also Mobility As a Service, by providing a full service trip planner that includes other modes.[54]

The proposed technology to be used is a mix of a mobile phone app with ANPR enforcement.

All light vehicles circulating within the jurisdiction of Brussels City (except on one orbital motorway used to bypass the city), would be required to have a mobile phone on the vehicle, operating an app that measures and reports distance travelled by location and time of day, and paired with the vehicle (by declaring its number plate). The app would measure road use, until the vehicle is detected as having departed the Brussels City Region. ANPR cameras scattered throughout Brussels will detect vehicle number plates, which will be processed to determine if the vehicles have a mobile phone with the app operating at the time of detection. Those that have not would be fined.

Singapore had previously investigated the merits of using mobile phones to collect road pricing fees, and some US jurisdictions have considered it (and it was noted in work undertaken for The Congestion Question). In all cases significant limitations with the technology were noted including:

- Requiring a mobile phone to be "on" and the app "on" before driving is likely to result in multiple drivers forgetting to launch the app, or choosing not to do so (and claiming technical difficulties)

[53] It is not proposed to apply Smartmove to heavy vehicles, which are already subject to the Belgian heavy vehicle road user charging scheme called Viapass (which charges travel on roads in Brussels a higher rate than in neighbouring federal states).
[54] A demonstration video is included here (French with English subtitles) https://smartmove.brussels/smartmove-c-est-quoi

- Difficulties in ensuring that the mobile phone app is "off" or not measuring travel when the phone is removed from the vehicle it is associated with (e.g., if the driver switches to a bus, can the phone detect whether it is no longer in the car?)
- Risk that a phone app for a vehicle with multiple drivers will see two phones measuring trips in parallel if both drivers travel at once
- Risk that a driver for multiple vehicles will enter the wrong number plate for the specific vehicle
- Concern that the mobile phone power supply is interrupted, either due to a faulty connection in the vehicle, a lack of suitable power, or the battery expiring
- The app being interrupted by other use of the phone (e.g., for entertainment, calls)
- Drivers unable to drive their cars if their phone is faulty.

Although the project was delayed due to the pandemic, it is now in a test phase. If successful, and it receives political approval, it is expected to be implemented in 2024.

Brussels presents an opportunity to test a technology that, if successful, would significantly reduce the costs of introducing *network based* urban road pricing on a wide scale. Given the ubiquity of smartphones in New Zealand (around 92% of households have one)[55], this offers potential for lower cost and more flexible application of urban road pricing in the longer term in Tauranga, if it can be made technically feasible. The growth in new vehicles with on-board in-vehicle telematics may equally provide a platform to more economically introduce network road pricing in the next 15-25 years.

Australia

Although three Australian cities have significant tolled roads networks (Sydney, Melbourne and Brisbane), none have commissioned any publicly available studies of urban road pricing to be applied to existing roads. There is limited interest at local, state and Commonwealth Government levels in urban road pricing in Australia. In part this may be attributed to the scale and levels of tolling in those cities, which is somewhat controversial.[56]

Most major motorway routes in Sydney are tolled (see Figure 17) with prices ranging from A$1.82 to A$8.89 for a single toll road, but a single trip can cost over A$15 for using multiple toll roads. As in Tauranga, all toll roads in Sydney have tolls to pay for the capital costs of the road or parallel route (in the case of Sydney Harbour Bridge), so perceptions from the public and politically are that tolls can be justified to pay for new infrastructure but are not acceptable for paying for existing corridors. Furthermore, Sydney has experimented modestly with peak pricing on the Sydney harbour crossings to manage congestion, but the results of this have been disappointing, largely because the surcharge at peak times is only A$1, which is insufficient to generate a meaningful demand response on top of a toll of A$3.

[55] Source: https://www.statista.com/forecasts/1143839/smartphone-penetration-forecast-in-new-zealand

[56] For example, https://www.smh.com.au/national/nsw/inconsistent-confusing-network-of-sydney-tolls-in-the-spotlight-20220425-p5afy1.html

The most significant studies into congestion pricing in Sydney and Melbourne was undertaken by the Grattan Institute thinktank in 2019.[57] The studies modelled introducing cordon pricing to the CBDs of both cities during peak times. The report indicated that as a first step a CBD cordon makes sense for those cities and would generate significant net revenues, but the key purpose of such schemes should be to relieve congestion.

The reasons for choosing a CBD cordon were:

- The highest concentration of employment is in the CBD (15%);
- The highest numbers of drivers to work go to the CBDs;
- The CBD has the highest concentration of car drivers per square kilometre;
- A high proportion of commuters to both CBDs use public transport (75 and 66% respectively);
- Most who would pay a CBD cordon would be higher income drivers;
- 21% of car trips in Sydney in the AM peak are for social, retail or recreational purposes (indicating that a proportion of such trips could easily be retimed with limited inconvenience) (11% in Melbourne).

The modelled results are that in Sydney, average speeds in the CBD would increase by 11%, with a 1% increase across metropolitan Sydney, in Melbourne average speeds would increase by 16%, with a 1% increase across the metro area. However, CBD cordons would be insufficient to significantly relieve network congestion beyond approaching roads. The report proposed corridor charges be introduced and modelled a rate of A$0.30 per km for such charges, which resulted in 10% faster average speeds on charged corridors, with 2% improvement across the network.

Although there is academic discussion about the merits of urban road pricing in Australia, concerns over the cost of tolls (especially given the annual CPI + increases in toll rate, and congestion on some toll roads) have generated considerable political reluctance to advancing urban road pricing that is not applied to new road infrastructure as tolls.

Although Tauranga has a small number of toll roads, there have not been the concerns raised about pricing or performance of those roads, as there have been in Sydney or Melbourne. However, the public perception of pricing as being equivalent to tolls may hinder communication if the primary purpose of urban road pricing in Tauranga is to improve road network performance. The key characteristic of tolls is that they are applied 24/7 at a standard rate, which may give rise to concern that any form of urban road pricing initially applied during peaks could be extended to 24/7 for revenue collection purposes. The dominance of Sydney and Melbourne CBDs on traffic generation for those cities is not paralleled in Tauranga, so should indicate that scheme options focused on Tauranga's more congested locations is more appropriate than an initial focus on its CBD.

[57] Source: https://grattan.edu.au/report/right-time-right-place-right-price/

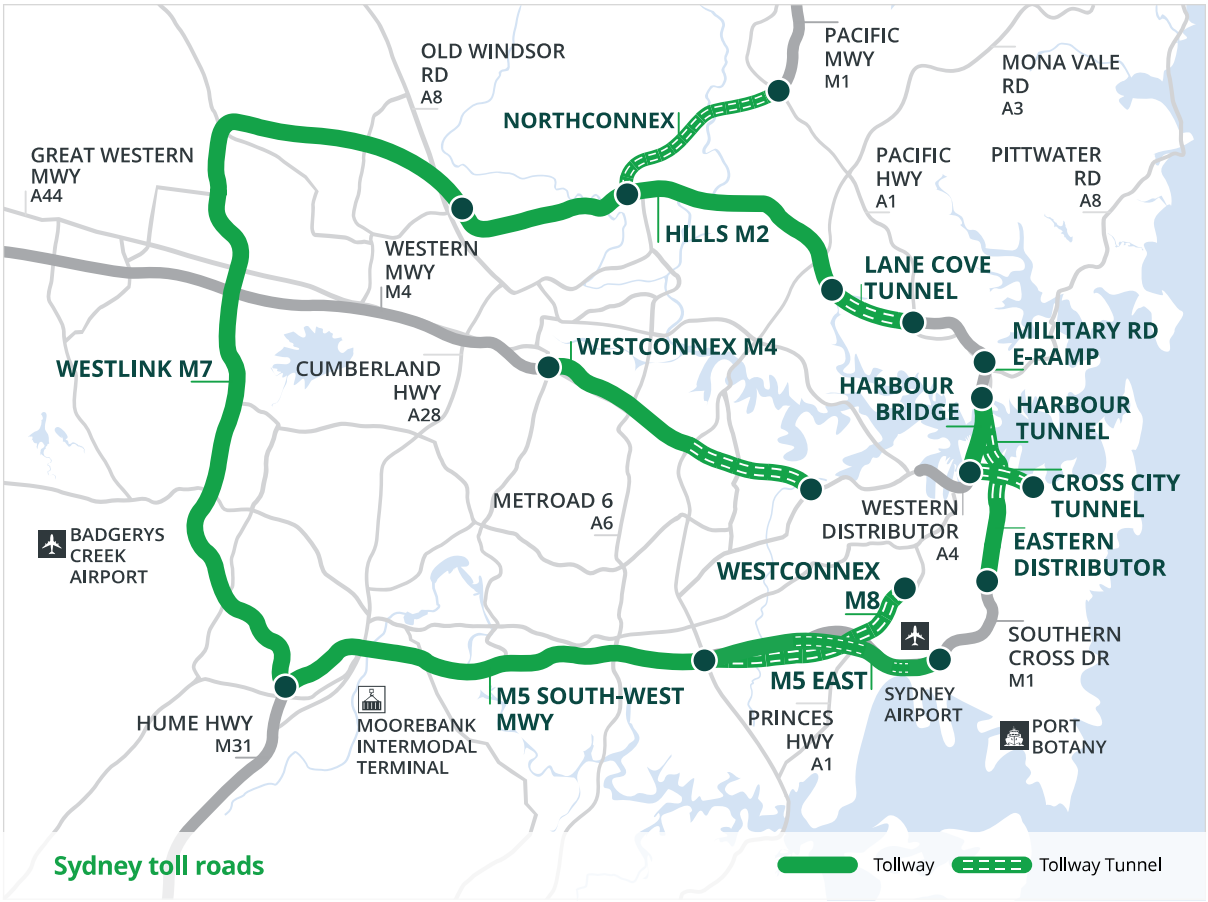

Figure 17 Sydney toll road network

Lessons on public acceptability

Undoubtedly the single biggest factor affecting whether or not urban road pricing is introduced is the acceptability of the proposed concept (and the package of complementary transport measures) to the general public.

By contrast, several larger cities with relatively high urban density and mode shares for public transport and active modes (and conditions as good as those of cities such as London and Stockholm which have introduced urban road pricing) have failed to introduce such systems. Amsterdam, Helsinki and Copenhagen have all tried and failed to introduce congestion pricing at least once in the past twenty years.

For example, Copenhagen, after some years of discussion, was to have congestion pricing introduced after the 2011 election of a government which included the policy in its manifesto. Copenhagen at the time has a mode share of around 33% of ALL trips by private car (<20% of commuter trips), with similar shares for public transport and active modes. However, Copenhagen was unable to introduce congestion pricing due to a mix of public and business opposition, and a drop in political interest (because forecasts of net revenues had proven to be higher than had been hoped). Opposition was focused on the location of charging points and the impacts on businesses at the periphery of the proposed cordon. It is *public acceptability* that is more critically important than the city's geographic and economic characteristics in determining whether or not a city introduces urban road pricing. Public acceptability includes (beyond general public opinion):

- Designing a system so that those who will likely pay will benefit from pricing and believe they will benefit (through shorter travel times, better trip reliability and/or improved infrastructure); and

- Ensuring that locations adjacent to where pricing is introduced are not disadvantaged (whether residents or businesses) from those less affected by pricing.

There is little doubt in policy or academic circles that urban road pricing can significantly reduce traffic congestion, as well as generate net revenues. As secondary consequences, urban road pricing also contributes to reducing emissions from motor traffic, and encouraging modal shift towards modes less or not subject to urban road pricing (whether public transport or active modes), as well as increasing available road capacity for such modes. It is clearly a powerful tool to enhance urban mobility, and reduce the negative externalities from high volumes of road transport.

However, there is considerable public scepticism about urban road pricing delivering net benefits either to those who would have to pay, or to those with businesses or homes affected by those who would have to pay. Although traffic congestion is frequently a major concern for residents of cities, belief that pricing existing roads will reduce this is low, because of a lack of trust that political decisions are made to benefit motorists, rather than to raise money.

Key to obtaining public support are the following elements:

- Promoting objectives that have broad public support. This includes reducing congestion and improving urban amenity. The public tends not to support urban road pricing promoted as revenue raising, unless net revenues directly improve conditions for those paying (e.g. Oslo's funding of an inner city bypass);

- Design a scheme that improves conditions for those who pay;

- Use of net revenues that is seen to generate tangible benefits (whether it be transport improvements that benefit those affected, or reduction in other taxes);

- Not applying charges at locations and times when congestion is not a problem;

- Starting at a scale that is commensurate to the city and the problem being addressed, with the flexibility to expand over time;

- Clearly communicating the objectives and how the objectives will be achieved, and how tariffs will be set and reviewed based on meeting those objectives;

- Including a complementary package of transport infrastructure measures that help contribute to the scheme objectives (e.g., more capacity for other modes, improved road capacity for vehicles bypassing the charging scheme).

1.10 New Zealand developments

Auckland

There have been three major studies into urban road pricing in Auckland commissioned by central and local government in the past 20 years. The Auckland Road Pricing Evaluation Study (ARPES) in 2006 was the first detailed evaluation of options for urban road pricing, which considered multiple options for both congestion reduction and revenue generation. This was followed by the Auckland Road Pricing Study (ARPS) in 2008 which considered two scheme options in more detail, called the Congestion Scheme and the Revenue Scheme.

The Congestion Scheme was an inner suburbs area charge scheme designed specifically to reduce peak time traffic congestion, by applying a fee to travel within that area between 0600-1000 weekdays. The Revenue Scheme was an inner suburbs cordon charge which would apply 24/7 with no variation at peak times. Neither scheme was carried further in analysis as Government focused on investment in major public transport and road projects.

The most recent study, called The Congestion Question (TCQ), was undertaken between 2016 and 2020. It emerged from parallel work called the Auckland Transport Alignment Project, which sought to achieve agreement between central and local government over capital investment in Auckland land transport over the medium term.

TCQ's main report was published in July 2020. The study was carried to investigate urban road pricing options for Auckland in light of the impacts of recent growth, completion of (and further plans to improve) major improvements to road and public transport infrastructure (e.g., Western Ring Route, commuter rail electrification and upgrades). The workstreams in the TCQ programme depicted in Figure 18.

The objectives for urban road pricing were explicitly included in its terms of Reference which:

required the TCQ to undertake design, testing and analysis of a shortlist of congestion pricing options to improve the performance of Auckland's road network by encouraging more efficient patterns of travel, taking into account economic, social and environmental outcomes.[58]

Throughout the TCQ study the objective of reducing congestion has been clear, in identifying scheme options and designs, and in assessing those options, and their economic, social and environmental impacts. Although it was recognised that urban road pricing could generate substantial net revenues, the revenue generation was acknowledged as secondary, alongside a range of other benefits such as improving air quality and reducing contributions to greenhouse gas emissions.

To give effect to that objective, the TCQ study considered a long list of options for initial evaluation to address congestion in Auckland, including urban road pricing scheme options and other pricing and non-pricing related options.

After defining the problem and developing and refining options, it evaluated a set of preferred shortlisted options, as well as investigating options for technology, the likely revenue

[58] The Congestion Question, Main Findings, July 2020, p.7.

outcomes, possible mitigations of negative impacts (e.g., traffic diversion, impacts on disadvantaged communities and businesses), and measures that would complement the possible options. A key conclusion is that Automatic Number Plate Recognition (ANPR) technology as used for tolling can be applied at scale for urban road pricing in Auckland, noting that technologies over the longer term may offer additional options.

Five shortlisted options were considered:

- City centre cordon (pricing entry/exit to downtown Auckland essentially bounded by SH1 and SH16);
- Isthmus area charge (pricing entry and driving within the Auckland isthmus bounded by Waitemata and Manukau Harbours, Blockhouse Bay/Waterview, Tamaki River and Southdown/Otahuhu;
- Strategic corridor charges (on congested corridor, whether State Highways or local roads);
- Combination of city centre cordon and strategic corridor charges; and
- Regional network charging (charging on all congested roads at congested times).

These were evaluated by network performance, practical assessment, social (distributional) impacts, environment assessment and cost/benefit appraisal. The evaluation conclusion was that a combination of the city centre cordon with a strategic corridor option had the greatest potential for positive impacts while mitigating negative effects.

The report noted:

The two preferred congestion pricing options differ in spatial scale and therefore their forecast impact on network performance. Both options represent workable solutions and have the potential to generate sensible trade-offs between improving network performance as a result of modifying travel patterns, and the requirement to minimise adverse social impacts.

Neither preferred option had the highest benefit-cost ratio, but together they did reduce delays by the highest proportion and performed best in reducing delays for freight and improving access to employment (by the measure of proportion of jobs accessible within a 30-minute drive). The city centre cordon scheme option has low impacts in itself but is a "viable and low risk" option in advance of implementing corridor charges, which themselves generate the greatest potential.

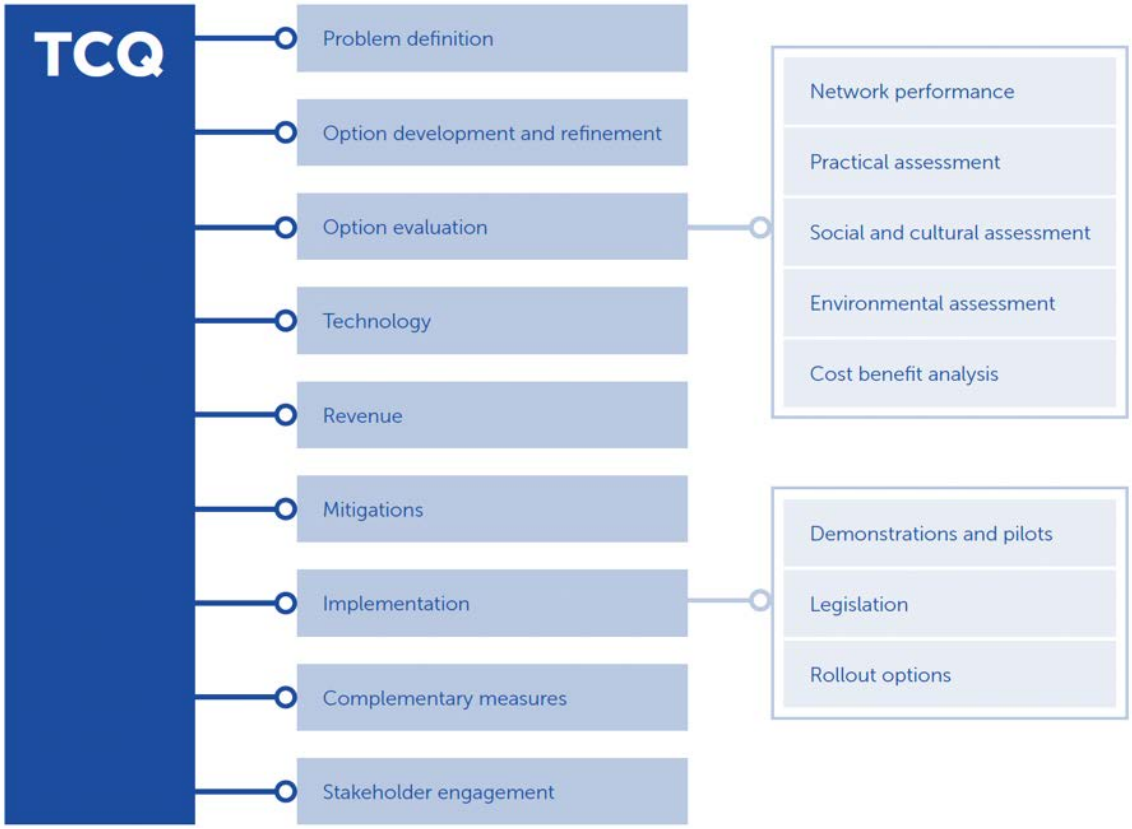

Figure 18 TCQ (Auckland) work programme

TCQ recommended:

Based on the technical work undertaken in the TCQ investigation, there is a strong case for implementing congestion pricing in Auckland for demand management purposes. However, prior to a final decision on whether or not to implement congestion pricing, the TCQ recommends that a comprehensive stakeholder and public engagement exercise be undertaken.

It is important to understand that the assessment of the corridor charging option (and indeed all of the shortlisted options) in TCQ did not include a detailed investigation into the exact locations where urban road pricing would be applied. Although some assumptions were made as to locations at which charging could be applied, (for the purposes of modelling) these were done for a strategic level analysis, not to depict the details of a preferred option. It was understood that there could be considerable debate over the exact charging points for a preferred option, when the purpose of TCQ is to obtain approval at central and local government levels for urban road pricing "in principle" to meet the programme objectives.

Please note that boundaries are indicative only

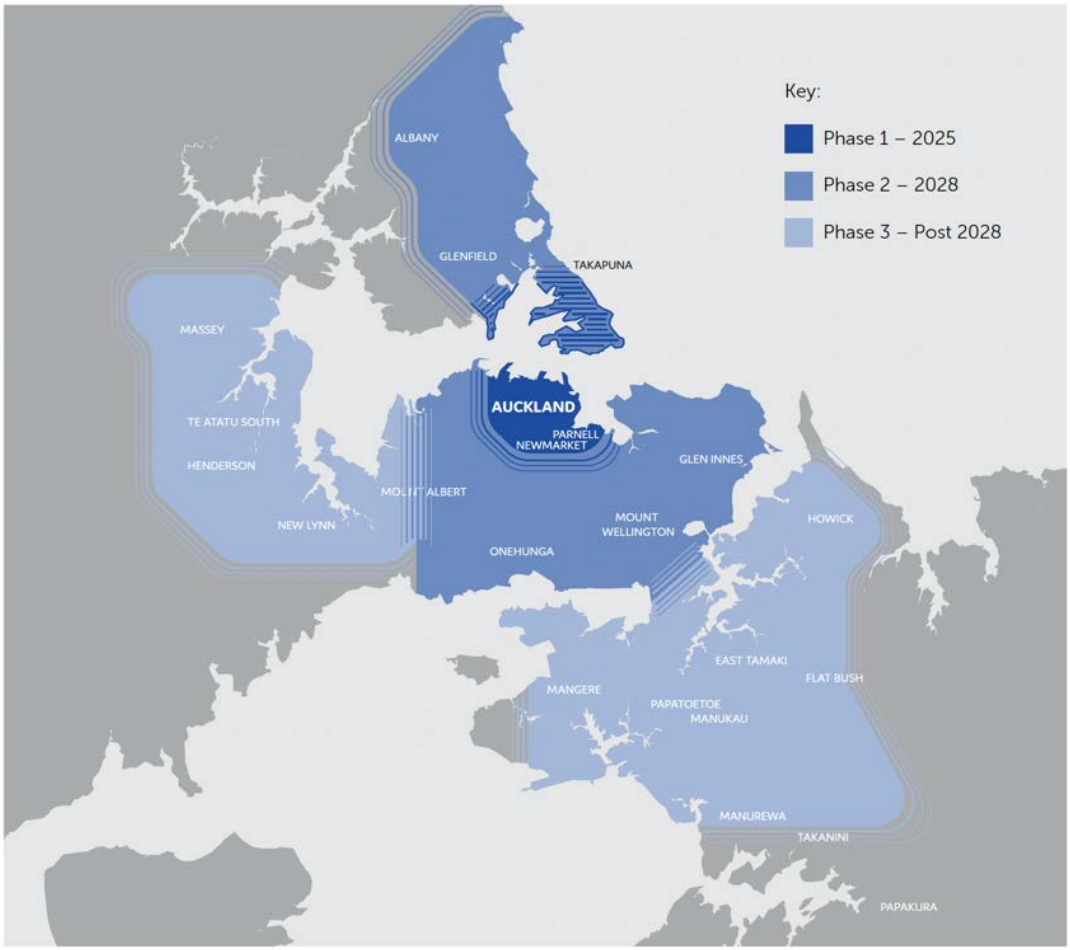

Figure 19 Auckland congestion pricing indicative phasing

The corridor charging concept for Auckland was defined as:

vehicles are charged to travel on congested corridors based on road hierarchy during congested periods.

Such corridors were not defined, but were recognised as including some combination of motorways, major urban arterials and relevant parallel arterial routes. The depiction of the preferred option illustrates this in Figure 19.

The inner-city cordon is depicted as Phase 1, which Phase 2 representing the area within which corridor charging might be introduced in the first instance, with Phase 3 as a later stage if required. As the scheme is defined as targeting congestion, its implementation and phasing would be expected to be determined by the impacts of each stage of implementation.

The rate structure option chosen was an access charge, rather than a point charge. This is similar to London rather than Singapore but does not prevent a shift to point charges at a future date. The key advantages of an access charge are:

- Simplicity of understanding (particularly for motorists unfamiliar with pricing)
- Only one vehicle detection needed (minimising risk of diversion or evasion)

- Ability to vary by time of day, but no need to vary by location

The indicative charging schedule is depicted in Figure 20, this demonstrate how access charges may be implemented with shoulder charges either side of peaks, with no interpeak charge. The proposed concept was that any vehicle entering the cordon or on charged corridors would pay the highest price for any two-hour period of travel (with higher charges for heavy vehicles, and exemptions for buses, emergency vehicles and motorcycles). Any final charging schedule may have different operating hours and tariffs, but this helps to illustrate what may be implemented in Auckland if approved.

Time	Period	Tariff
06:00-06:29	Shoulder	$1.50
06:30-06:59	Shoulder/Peak	$2.50
07:00-07:29	Peak	$3.50
07:30-07:59	Peak	$3.50
0:800-0:829	Peak	$3.50
0:830-08:59	Peak/Shoulder	$2.50
09:00-09:29	Shoulder	$1.50
09:30-15:29	Interpeak	No charge
15:30-15:59	Shoulder	$1.50
16:00-16:29	Shoulder/Peak	$2.50
16:30-16:59	Peak	$3.50
17:00-17:29	Peak	$3.50
17:30-17:59	Peak	$3.50
18:00-18:29	Peak/Shoulder	$2.50
18:30-18:59	Shoulder	$1.50
19:00-05:59	Off-peak	No charge

Figure 20 TCQ indicative tariff schedule

The outcomes modelled from the preferred option combination include:

- 8% reduction in average vehicle travel times;
- 35% reduction in total vehicle travel times;
- 19% less time spent in severe congestion;
- 26% less VKT of freight travelling in severe congestion;
- 19% more jobs accessible within a 30 minute drive;
- 0.7% reduction in CO_2 emissions
- 0.8% reduction in other (noxious) emissions (e.g., $PM_{2.5,}$ and NO_x)

These impacts were described as being broadly similar to the impacts of the school holidays on peak traffic, with reductions in traffic volumes by around 8-12% on average at peak times.

If it is decided to proceed with urban road pricing for Auckland, legislative change is required (as it would be for Tauranga), and a detailed design phase would be entered. That phase would include a detailed traffic study to identify the best locations for charging points, and the infrastructure and business rules required to address any localised issues (such as vehicle diversion, or provision for access for residents that may be stranded by a charging scheme). For example, Stockholm's cordon scheme has long included an exemption for access to Lidingo Island (which is located within the cordon) which is enforced by measuring time taken to travel between two charging points.

In 2021, the Transport and Infrastructure Committee of the House of Representatives held an Inquiry into Road Pricing in Auckland, which called for evidence on a wide range of issues and considerations around the merits of allowing road pricing to be introduced in Auckland. It concluded with eight recommendations, broadly supportive of the conclusions of TCQ.

Wellington

Let's Get Wellington Moving (LGWM) has not yet commissioned a detailed study into options for urban road pricing for Wellington. However, the concept of implementing some form of urban road pricing to support LGWM objectives has been considered, at a high level, in multiple LGWM documents for some time. A study on commuter parking levies was published in April 2021, which considered its merits as a source of revenue and to effect modal shift. It is worth noting that LGWM has already found that private car use entering the central city at peak times has been at declining levels for some years, so there is not a major issue of growing congestion due to commuter car traffic into the city. However, the geography of Wellington means some corridors (including SH1 bypassing the city and Te Aro) have severe congestion during peak and occasionally at inter-peak periods.

This was followed by an initial assessment of congestion pricing, which was published by LGWM in August 2021. That assessment indicated that urban road pricing in Wellington could contribute to a range of policy objectives. It considered a handful of concepts including a city centre cordon, an inner suburban area charge and a corridor scheme. These were presented only as high-level concepts, with the city centre cordon modelled as an illustration of what urban road pricing might achieve in transport outcome metrics.

The results of that modelling were that a peak time only, inner city cordon, bounded by State Highway 1 to the north, west and south (and Kent/Cambridge Tce to the east), could generate:

- 10% reduction in VKT travelled within the cordon zone, with a 3% reduction in VKT across Wellington City more widely
- Travel times on most corridors improve, except for one corridor (likely due to change in route choice to a corridor with constrained capacity)
- 8-20% increase in public transport patronage on key corridors

The report also indicated that the additional demand would likely require increases in public transport capacity on some corridors, enhancements to active travel within the cordon zone, and some redirection of road capacity spending from routes towards the cordon, to routes bypassing the cordon.

LGWM is expected to commission a more detailed study into options for urban road pricing within the next year, but has yet to determine what the primary objectives of such a scheme would be. Clarity on such objectives will significantly influence the choice of scheme options, geographic and temporal scope. Regardless of the objectives, it is likely key elements of a scheme for Wellington would include:

- Use of ANPR technology to detect vehicles;
- A cordon around central Wellington or a small number of corridor charging points;
- Peak only charges (except perhaps for one or two corridors);
- Complementary enhancement of public transport capacity on corridors servicing the priced roads.

Relevance of Auckland and Wellington examples to Tauranga

The TCQ study's relevance to Tauranga is in its process for developing and evaluating options. Notable conclusions from the TCQ relevant to Tauranga include:

- The merits of agreeing to a single objective to develop and assess options (in this case, seeking to improve road network performance, whilst also noting revenue potential and environmental impacts)
- Use of ANPR technology is appropriate for a large-scale urban road pricing scheme in Auckland
- Assessment of options at a strategic level can deliver indicative conclusions as to the merits of pricing and the likely best strategic options, without finalising the details of exact charging locations or times
- Corridor charging is technically feasible and is likely to have the greatest benefits, given that (beyond central Auckland) other locations of activity are not well suited to implementing cordons to reduce congestion
- Access based tariffs can deliver significant benefits, without reducing the flexibility to implement point-based (distance oriented) charges at a later date.

There are merits in considering the approach taken by TCQ in any future more detailed investigation of one or more preferred options for urban road pricing in Tauranga. Given all of the studies into road pricing in Auckland, the clear conclusion is that beyond the scale of central Auckland, a cordon scheme is not recommended for Auckland. Any positive impacts on demand are more than offset by significant negative local impacts on residents and businesses where urban form is more diverse than within the city centre, and concentrations of traffic congestion are on major corridors, not on other key urban centres in metropolitan Auckland.

Wellington's investigations are still at a very strategic level. Although it appears likely urban road pricing could have significant positive impacts on the Wellington transport system, until a decision is made on the primary objective for road pricing in Wellington, it is difficult for a detailed study to be undertaken that can develop and evaluate options based on such an objective. Wellington's urban form, employment patterns and transport system would appear to suit some form of urban road pricing focused on the Wellington downtown area, or on the

small number of constrained corridors that are highly congested at peaks. However, the geographical location of pricing will significantly affect the trips that it would target, and the suitability of alternatives for those affected by pricing. A key issue is likely to be whether through traffic (traffic from the north, such as the Hutt/Porirua travelling to southern/eastern suburbs, such as Wellington Hospital and Airport) is subjected to pricing as well as traffic entering the central city. There are also careful design choices to be made as to their impacts on residential and commercial locations.

For Tauranga, some similar issues are relevant. Any pricing scheme will need to consider the geographic impacts on trip patterns, especially those not likely to shift time or mode of travel (e.g., longer distance trips bypassing Tauranga) and localised impacts on residents and businesses that may be adjacent to a charging point.

1.11 Public policy issues

This section summarises how other jurisdictions that have implemented urban road pricing have addressed the following key issues:

- Ownership and management of net revenues;
- Governance and management of transport networks in the jurisdiction, including the governance of roads, public transport and parking relative to road pricing.

Ownership and management of net revenues

In most jurisdictions, the ownership and management of net revenues is controlled either by a single entity or is determined by a multi-year agreement across central, regional/state and local government jurisdictions, associated with a package of transport expenditure supported by a range of revenue sources. Key to public acceptability for urban road pricing is that there is clear accountability for the use of revenues, and that the public knows what the revenue is used for (as it is distinct from tolls which are identified as raising revenue to pay for the capital costs of the tolled road).

Singapore: Unlike all other jurisdictions, Singapore regards net revenues from its ERP scheme to be general revenue for central government. None of the revenue is hypothecated, and it bears no relationship to funding for transport. The Singapore LTA explicitly manages the ERP scheme as a traffic management tool, and seeks to collect fees efficiently and effectively, but neither has a target for revenue, nor is influenced by expected net revenues in recommending changes to ERP prices. Although not explicitly stated, it may be considered that Singapore's ERP revenue is a form of return on capital expended on the network, with that return treated like other government commercial assets.

London: In the UK, all local authorities have the legal power to introduce congestion charges but are legally required to use net revenues from such fees on local transport projects and maintenance within their jurisdiction. Similar legislation applies to the jurisdiction of the Mayor of London and Transport for London. Although Transport for London is the road controlling authority for only the major arterial roads in London (see Figure 21), it has the powers to implement pricing on local authority roads that are essential to enabling pricing to operate effectively.[59]

The governance framework for transport in London means that use of congestion charge revenues is almost entirely up to the discretion of the Mayor of London as part of the development of the budget for Transport for London. This is subject to oversight from the London Assembly but is essentially reserved to the Mayor to determine the strategy and how net revenues are used to support that (including the mix of modes and projects it can support). In that respect the revenue is treated like all other local revenue collected by Transport for London (including public transport fares and fines from the ultra-low and low emission zones).

Central government has, until recently, largely treated London's congestion charging revenue as being not relevant to its own funding grants provided to London to support its transport infrastructure and services. However, since 2015 there has been an ongoing debate between

[59] Other roads are governed by 32 local authorities and motorways/major A roads by National Highways.

the UK Government and the Mayor of London over the extent to which London should contribute towards paying for its own transport needs through the revenue collection means it has under its control. Originally the UK Government was seeking to end all central government funding to Transport for London, but the pandemic resulted in four emergency funding deals set up to help cover the significant losses in fare revenue from 2020-2022. In August 2022 a funding settlement was reached between the UK Government and the Mayor of London, which seems to have been supported by a permanent extension in the congestion charge operating times. Part of the deal for the bailout of Transport for London included increasing the fee (from £11.50 to £15 per day) and operating hours for the congestion charge (which now operates 1200-1800 Saturdays and Sundays, as well as 0700-1800 weekdays).

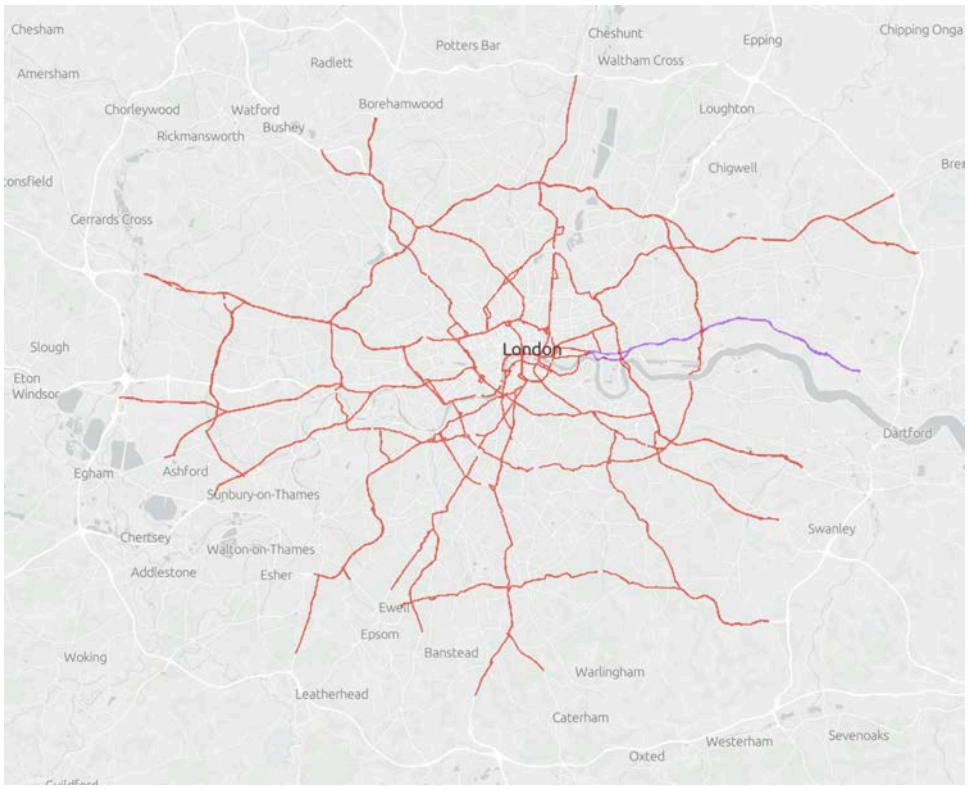

Figure 21 Transport for London's road network in the context of metropolitan London's roads

Stockholm and Gothenburg: Introduction of the congestion tax in Stockholm (and in Gothenburg) was undertaken by the Swedish Transport Authority – a central government agency – and in theory, the use of net revenues could be determined entirely by that entity. However, in practice central government and local authorities have sought to enable public support (or in the case of Gothenburg, acquiescence!) by setting up multi-year transport funding packages that bundle other central and local funding sources with the congestion tax, to support spending on a range of capital projects. For Stockholm this was, initially, focused on using the congestion tax to pay for the 21km long E4 Stockholm Bypass project.[60] For Gothenburg, the "West Swedish Package" of capital projects was agreed, and indeed the debt raised to pay for that package requires the Gothenburg congestion tax to service it. More recently, changes in central and local government in Sweden and Stockholm saw a new transport package authorised (The Stockholm Agreement 2013), to use net revenues to

[60] More details at https://bransch.trafikverket.se/en/startpage/projects/Road-construction-projects/the-stockholm-bypass/

support new metro lines in Stockholm (although funding was already committed to the E4 project, the mix of total spending and sources of revenue is altered as governments change).

In effect, the key policy changes related to the urban road pricing schemes in Sweden are not significant in respect of the congestion tax schemes themselves, but rather government decisions on the use of net revenues, which are treated as just another source of revenue to contribute towards transport spending. There are some parallels to past agreements for transport funding between Auckland and central government, such as through the Auckland Transport Alignment Project (ATAP), although in Sweden such packages are negotiated regularly every few years. The packages see the relevant central government agencies agreeing to deliver the package of capital improvements (e.g., Swedish Transport Agency for the congestion tax, Swedish Transport Administration for rail infrastructure and state highways, and local authorities for local roads, metro, light rail and bus infrastructure), funded from the relevant jurisdictions (central and local authorities). Changes in government after elections can see any elements of those packages up for renegotiation, for example, if a new government wishes to propose another project (and drop one that is not yet committed to construction), it can choose to do so, noting that negotiations for new transport funding packages can take as long as two years.

Does pricing get co-ordinated more widely?

From a wider transport planning and transport economics perspective, there may be merit in co-ordinating the broad range of urban transport pricing interventions, and complementary non-pricing policies, so that the impacts are harmonised and not contradictory. For example, the impacts of urban road pricing will be influenced by policies on parking pricing and availability, other fees on road use and vehicle ownership, and the pricing of alternative modes. However, most jurisdictions do *not* take a comprehensive approach across such tools, in part because many do not have the powers across many of those policy levers, but more likely because it increases the complexity of introducing urban road pricing.

Singapore is the jurisdiction with urban road pricing which has the greatest centralisation of powers and potential to co-ordinate charges across car ownership, parking, usage and public transport usage, along with regulations on car use.The introduction of ERP paralleled increases in the numbers of vehicles permitted to be registered in Singapore and a reduction in vehicle ownership fees, indicating a shift from taxing *owning* a vehicle to *using* a vehicle. However, ERP in Singapore is still seen as complementing measures to constrain the rate of growth of car ownership, and its success should be acknowledged as being within that context. Car ownership in Singapore is expensive, yet Singapore has demonstrated that it can manage demand for car use on busy roads effectively with road pricing. The primary complementary policy measure alongside ERP (and the previous ALS and RPS schemes) were in enabling expansion of public transport services, including capital investment in the metro scheme, and expanding bus service routes and frequencies. Policy on fares has not been directly related to ERP, in part because a significant proportion of the population (around 50%) does not own a car. Likewise, policy on parking has for some time discouraged kerbside use in central city areas except for loading/unloading.

In London, the Mayor of London has powers over PT fares, but not parking charges set by local boroughs, let alone private businesses. However, no changes to fares were implemented in co-ordination with the congestion charge, and local boroughs have also continued to set kerbside (and off-street publicly owned) parking charges according to their own revenue and transport management policy priorities. For the Mayor of London, the key complementary measures implemented with the congestion charge were increased bus service frequencies and road infrastructure changes along the area boundary to mitigate traffic diversion impacts. Transport for London has actively pursued road management measures to enhance access and safety for active modes and buses, but this is a general policy and is not directly linked to

the congestion charge. London boroughs which have roads covered by the congestion charge area have adopted their own policies on parking and kerbside management. It is notable that subsequent to introduction of the congestion charge, the Mayor of London was more readily able to re-allocate more road space to bus lanes, cycle lanes and widening footpaths to support growth in use of other modes. This was noted by Transport for London as *increasing*

Road space reallocation and the scale of development in London have resulted in reducing the road capacity available for car users in certain areas. This has led to a reduction in traffic volumes, but static (and more recently, rising) levels of congestion.[61]

In both Stockholm and Gothenburg, congestion tax is managed by the Swedish Transport Agency, which works in co-ordination with the public transport and road managers in both cities. However, the introduction and changes to the congestion taxes in both cities are not matched with specific changes to policies on parking or fares. As with London, the primary interventions have been to increase the frequency of public transport services on corridors crossing the charging points, and to adjust signage, rules and intersection designs on routes approaching charging points, to mitigate the impacts of traffic diverting to avoid being charged. As in Singapore, Stockholm and Gothenburg had previous policies to support greater use of public transport, and active modes and discourage parking in the central cities, which the urban road pricing schemes complemented.

The Norwegian urban road pricing schemes are almost universally intended to support significant infrastructure investments, so are co-ordinated with the opening of new roads or public transport links, and the infrastructure related to those, but are not seen as affecting other fees or fares.

It appears that the challenges of introducing urban road pricing are, in themselves, sufficiently daunting for most jurisdictions to not present them as also justifying approaches to other charges, or policies that may increase the difficulties in obtaining social licence and political approval to implement the pricing schemes themselves. However, as parking, public transport and road/kerbside management continues after such schemes are introduced, there can be little doubt that the *effects* of urban road pricing, in reducing congestion and diverting traffic by time and location, are reflected in how other urban transport measures are adjusted over time. London has used its scheme to reallocate road space, at the cost of increasing congestion, Singapore has seen its scheme enhance demand for public transport improvements and indirectly, supports their viability.

Governance of transport

In only one case is the governance of transport integrated in a single agency as a road controlling authority, public transport planner and funder, parking authority and road pricing operator, and that is Singapore. As a city state, Singapore has no local government, and manages all of its roads, commuter public transport and on-road parking through the Land Transport Authority. Singapore therefore effectively manages all of these elements together, and has done so for many years. In other examples, transport governance is split across multiple agencies, although the decision on the entity responsible for road pricing has taken into account the need for an organisation that has some specific capabilities and complementary responsibilities, in no cases has a single agency been established that has universal powers across all key land transport supply and regulatory functions.

[61] Source: "London stalling, reducing traffic congestion in London", London Assembly Transport Committee, 2017, p.19

London: Transport for London has a wide range of powers as an integrated transport authority for London, but there are some key limits to its authority. It is a road controlling authority for major arterial roads in London, and although it sets road rules for its network (including parking), revenue from parking on its roads is collected by the relevant local authority. Most roads in London are governed by 32 local authorities, although Transport for London can impose congestion pricing and low emission zones on their roads, as part of a wider metropolitan scheme seeking to manage traffic and its effects across a mix of arterial and local roads. The motorway network in London remains governed by National Highways (a UK Government owned company) and Transport for London has no authority over the motorway network (and cannot introduce congestion pricing on those roads). Transport for London has *influence* over local authority roads in London because it is the conduit for central government funding to local authorities for their road network (and local authorities apply to Transport for London under central government funding programmes for their road networks).

However, Transport for London does have planning, fare setting, contracting and funding powers over most public transport in metropolitan London, including the Underground, Overground rail, bus and tram networks. It does not have such powers over rail franchises that provide commuter services in London *and* neighbouring counties outside the jurisdiction of the Mayor of London, which includes a significant proportion of rail services to south, south-west and south-east London, and some services through east London.

Although Transport for London clearly implemented changes to the road network adjacent to the congestion charge when it was introduced (and subsequently afterwards, to reallocate road space to buses and active modes), and enhanced bus services to respond to expected changes in demand, the London congestion charge has not changed substantially since 2011 (when the Western extension was abolished). There have been few changes to road or public transport service provision in response to the congestion charge in recent years (indeed, the main responses have been to introduce temporary exemptions to the charge during the pandemic, to reflect the low level of public transport service provision, to as to support emergency and health workers during that period). In recent years, the Mayor of London has focused on the implementation of ultra-low emission zones as his primary transport policy objective has been to address local air quality issues. This has not seen implementation of any notable changes to public transport or parking policies.

Stockholm and Gothenburg: The Swedish Transport Agency as the owner and operator of the congestion tax systems in Stockholm and Gothenburg is a subsidiary entity of the Swedish Transport Administration, which is the central government manager of the state highways and rail network (but not rail services). In both Stockholm and Gothenburg, the Swedish Transport Administration is a road controlling authority for state highways, but not local roads, all of which are the responsibilities of local authorities. In Stockholm, 26 local authorities are road controlling authorities, but Gothenburg is mostly located within 1 local authority. Public transport in Stockholm is managed by a separate entity, Stockholm Public Transport which itself is governed by the equivalent of a regional council called Region Stockholm (which is elected alongside municipalities). This entity sets fares, levels of service and contracts services and operations to the private sector. This has some parallels to the separation of road and public transport responsibilities in New Zealand (except for Auckland), with a central government entity and local authorities as road controlling authorities, but a regional government entity responsible for planning, funding and management of public transport. As in London, each road controlling authority is responsible for its own parking

policies. Gothenburg has a similar structure, with a regional government responsible for public transport, with the local authority responsible for local roads.

Key to the success in Sweden has been the willingness of the Swedish Transport Agency to co-ordinate with both regional and local government in Stockholm (and Gothenburg) for the introduction of the congestion tax schemes in both cities. In both cases a mix of central government and local authority roads have been included in the pricing schemes, and in both cases, agreement was sought over the provision of enhanced public transport services. Although no single agency was responsible for all relevant infrastructure, agreement on the transport funding packages that accompanied the decision to introduce the congestion taxes in both cities incentivised the relevant agencies to work together for the pricing schemes to be able to function effectively. This includes agreement on the need for changes to road infrastructure (ranging from signs to changes in traffic signal phasing, and intersection redesigns to accommodate changes in traffic volumes), and public transport services and frequencies.

Price setting of existing schemes

With the exception of Singapore, all other jurisdictions with urban road pricing schemes review prices at irregular intervals. The key influences on such reviews in terms of timing and scope are:

- Timing in relation to local elections
- Effects of inflation on revenue and effectiveness of pricing on demand management
- Monitoring of traffic conditions, including any significant deterioration in travel times
- External events (e.g., pandemic)

London, Stockholm, Gothenburg and Oslo have all increased prices (and varied operating hours) on their urban road pricing schemes periodically to reflect such factors. In most cases, growth in traffic volumes and the effects of inflation are used to justify increases timed after local elections. Most recently in London, the need for additional revenue and the conditions of an agreement with central government saw operating hours for the congestion charge extended into the weekend, and the charge rate increased. However in those cities, charges are not adjusted regularly in response to changing conditions, unlike in Singapore. In London, the Mayor of London has regulatory powers to change congestion charge fees directly by order, albeit central government has powers to grant exemptions in addition to those powers held by the Mayor. This process is akin to the bylaw process seen in local government in New Zealand, but can be exercised by the Mayor solely. Stockholm and Gothenburg's rates can only be changed by legislation, so it is not legally able to be highly responsive to changes in traffic conditions. Norway similarly, is governed by legislation, so there is similarly little ability to change rates regularly.

Singapore, by contrast, has more flexibility in its process. Although rate changes need Ministerial approval, the Land Transport Authority makes recommendations quarterly on changes to ERP rates. These can be adopted by the Minister as a "rule" (equivalent to regulation in New Zealand, except it does not require Cabinet approval).

To date, no jurisdiction that has implemented urban road pricing has devolved full rate setting powers below that of a political decision-maker. Even Singapore retains final authority with

the Minister, although its public policy culture lends itself to be less affected by public whims than governments in the other countries with urban road pricing schemes.

It seems highly likely that as more urban road pricing schemes are implemented, that are performance based, there will be a need to have more flexible price setting arrangements than exist in other jurisdictions. Guidance for options for such approaches could be seen in the examples of sectors such as electricity lines charges and airports.

Conclusions for Tauranga

Any decision to proceed with urban road pricing in Tauranga (beyond existing toll roads) should include a decision on where responsibility will be for decisions on the use of net revenues. This could consist of agreeing to urban road pricing as part of a wider package of infrastructure improvements and using net revenues to support that package for a number of years (effectively what has happened in Gothenburg), so there is little scope to amend the use of such revenues until after such projects have been completed and funded (or if debt funded, once debt is significantly repaid). Another approach would be to treat the net revenues as additional funds available to be allocated to transport projects in Tauranga or associated with Tauranga, and for such funding to be determined by Waka Kotahi as part of its National Land Transport Programme funding process. To fully utilise this, there may be merit in treating such revenue as a means to access financing so that the costs of major projects can be spread over subsequent years of operation. It is expected that any legislation to enable urban road pricing will include a process and governance structure for decision-making on the use of revenues, but it should also include decision-making on reviewing the setting of price rates, and business rules for the pricing scheme. Unlike conventional tolls (which set a relatively simple schedule of rates applying 24/7 on a specific road, to raise revenue for that road), urban road pricing rates schedules can become complex and vary by location and time of day. Similarly, the revenue use is likely to be broader than funding the roads subject to pricing. Stakeholders and the public will want to know who makes those decisions, and the basis for reviewing price rates (up or down), and the use of revenues, before they might be willing to accept any such pricing concept for Tauranga.

More broadly, consideration of road pricing for Tauranga raises questions about the most appropriate governance structure for land transport in the city. At present in Tauranga there are three road controlling authorities (Waka Kotahi,Tauranga City Council and Western Bay of Plenty District Council) and the regional council (Environment Bay of Plenty) is responsible for public transport. Compared to jurisdictions overseas with urban road pricing, this is not a particularly complex structure to manage an urban transport network. Most cities with urban road pricing have at least two road controlling authorities, some larger ones have many more, suggesting there is not significant pressure to have a single entity. However, to enable urban road pricing to be introduced and developed over time, one entity does need to be responsible for the operation and management of the scheme and does need to have some powers that can be exercised on roads of more than one jurisdiction, for the purposes of the scheme itself (see London and Stockholm). It does *not* mean it needs to take over maintenance, management or parking on such roads. However, there *does* need to be a clear co-ordination between the provision of public transport and the introduction of urban road pricing, for the latter to be effective in achieving modal shift towards the former. It is outside the scope of this paper to evaluate the effectiveness of Environment Bay of Plenty in this role, but more broadly as Tauranga grows, it is appropriate to consider the right mix of incentives and powers for the agencies responsible for implement significant improvements in Tauranga's

transport networks and system in the coming years. Experience elsewhere does *not* indicate that there are decisive benefits in having a single transport agency across all roads and public transport, or that integrating local roads and public transport into one agency would have notable advantages over retaining separate entities. However, it is critical that in locations with multiple entities, that they have a framework to co-ordinate and work together and that the responsible agency for urban road pricing, have adequate powers to implement pricing across all the roads needed to make a scheme effective, efficient and viable.

1.12 Conclusion

Few cities have introduced urban road pricing, not because the economics or technology make it difficult, but because of the political and public acceptability issues of introducing fees on existing roads. This is often perceived as simply being another tax, rather than a way to fix an underlying problem with the supply of road space, that it gets rationed by queuing in the absence of price. For Tauranga to advance urban road pricing, it will need to ensure there is sufficient public acceptability to proceed.

A wide range of cities of various sizes have introduced urban road pricing (defined as pricing existing roads with peak time charges) of various forms, with a range of different objectives. It is critical that a primary objective be selected for urban road pricing schemes so that the geographical and temporal scope of the scheme is appropriately designed for that objective, along with a rate structure. Whether the objective is congestion mitigation, revenue generation or environmental enhancement, urban road pricing will also contribute to the other objectives, but the key objective should drive more detailed assessment and research. In Auckland, TCQ study has been focused on reducing congestion and produced a preferred solution based on balancing that objective with the relative costs and impacts of alternatives. Successful schemes in Singapore, Stockholm, Oslo and Milan have all met their objectives in addressing congestion, generating revenue or reducing emissions, because those objectives clearly directed scheme design elements. Tauranga should also be clear on its primary objective before it refines a preferred option for detailed assessment. Objectives affect key elements such as:

- Scheme operating hours
- Geographic scope of charging
- Application of discounts and exemptions
- Rate structure

Although there is extensive experience in applying dynamic road pricing to individual *lanes* on motorways, and success in using them to optimise utilisation of such lanes, dynamic road pricing (as defined in this paper) is neither necessary nor desirable to apply in an *all lanes* situation as is proposed in Tauranga. Singapore has successfully managed congestion using variable road pricing, with regular reviews of tariff levels at different locations to meet network performance targets. The success of variable pricing comes from providing certainty to road users as to the price at a particular time and location, but being able to review and adjust prices (up or downwards) to meet scheme objectives. Dynamic road pricing can do this, but does not offer certainty to drivers when commencing a journey. In all lane pricing scenarios, as proposed for Tauranga, this means that the *dynamic* element is unlikely to be effective (as drivers will simply factor in the range of prices they might face and choose to drive or not). Cities with lengthy experience in *all lanes* urban road pricing (like Singapore, Oslo, London and Stockholm) have not implemented or seriously considered dynamic road pricing because they see insufficient merit in doing so. Tauranga should consider advancing a variable road pricing solution over dynamic pricing, noting that there would be flexibility to move to dynamic pricing at a future date.

Although Tauranga has a lower population, population density and significantly lower mode share for public transport than most cities with urban road pricing, this should not be a

barrier to implementing some form of urban road pricing. Several cities in Norway have similar populations and densities (although significantly higher mode shares for public transport and active modes), although in all cases the policy objective has been to raise revenue to support capital spending on transport networks (both roads and public transport).

Most urban road pricing schemes have been implemented in stages, with initial implementation being on a smaller scale (e.g., Singapore and Oslo's inner cordon, Stockholm's cordon without through route), before expanding geographic scale and scope over time. Whatever scheme option may be progressed should be capable of implementation in stages, with the flexibility to adjust geographic and temporal elements over time.

Singapore and Brussels are the only cities currently implementing or testing a next generation of technical options for urban road pricing. Both are doing so on a scale much larger than Tauranga but may enable technical options for network scale urban road pricing to be considered over the longer term.

The TCQ study for Auckland has been New Zealand's most comprehensive study into urban road pricing for some time, and offers some useful lessons for Tauranga:

- Confirm scheme objectives before assessing scheme options
- A preferred scheme need not have all geographic and operating details determined for assessment purposes
- Corridor based charging is likely to offer the greatest benefits in reducing congestion and generating revenue (although for Auckland, a CBD cordon would also support objectives)
- Flexibility and scalability are important characteristics in assessing scheme options.

LGWM has yet to determine objectives for urban road pricing in Wellington, so has not yet commissioned a detailed study into options for pricing. Preliminary studies indicate promising potential, but a likely need to consider:

- Additional public transport capacity to accommodate mode shift; and
- Additional road capacity on corridors any traffic may be diverted onto (that is not subject to pricing).

Appendix – Norwegian urban road pricing schemes

Figure 22 Trondheim cordon charge points

Figure 23 Tonsberg cordon charge points

Figure 24 Stavanger cordon charge points

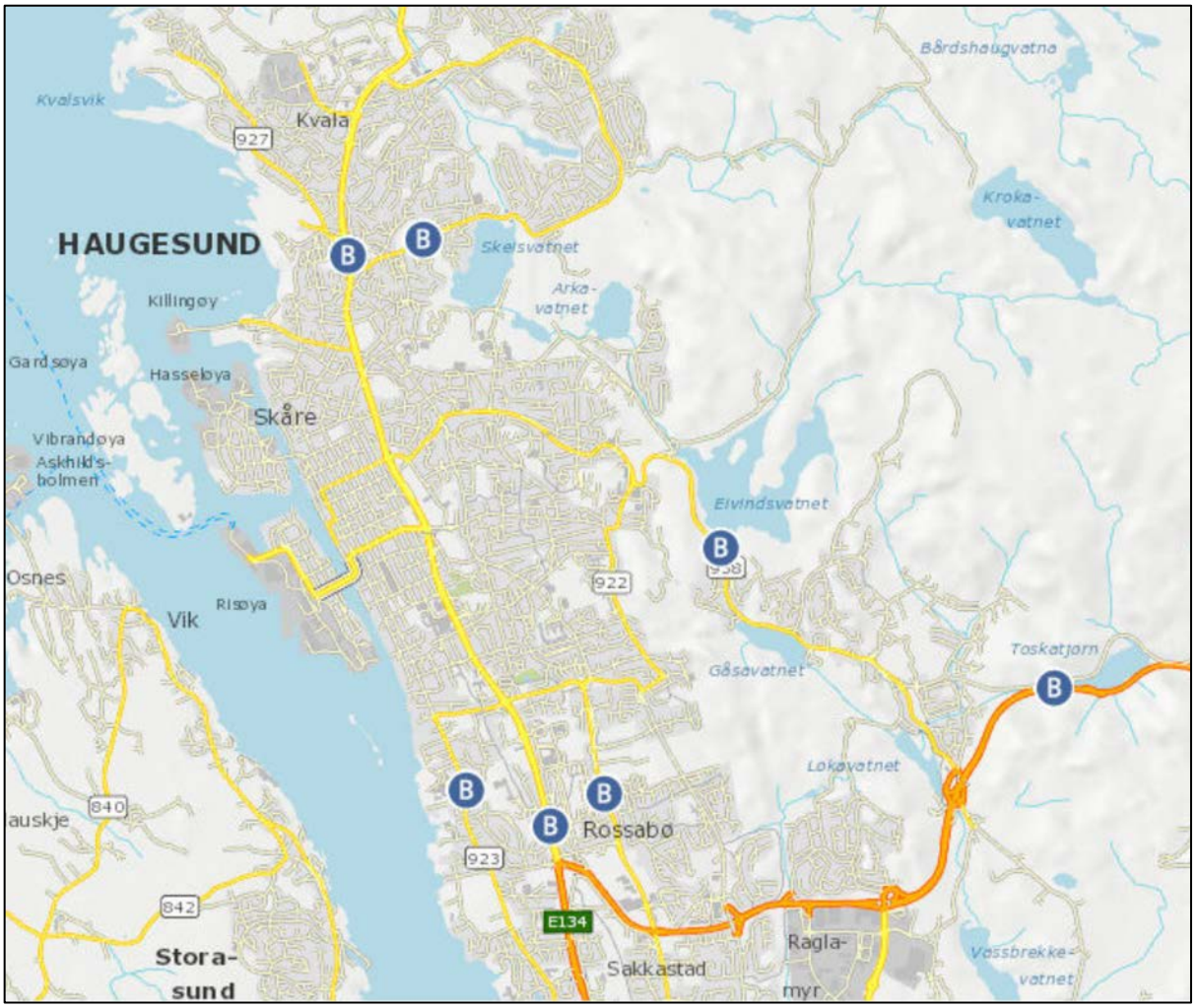

Figure 25 Haugesund cordon charging points