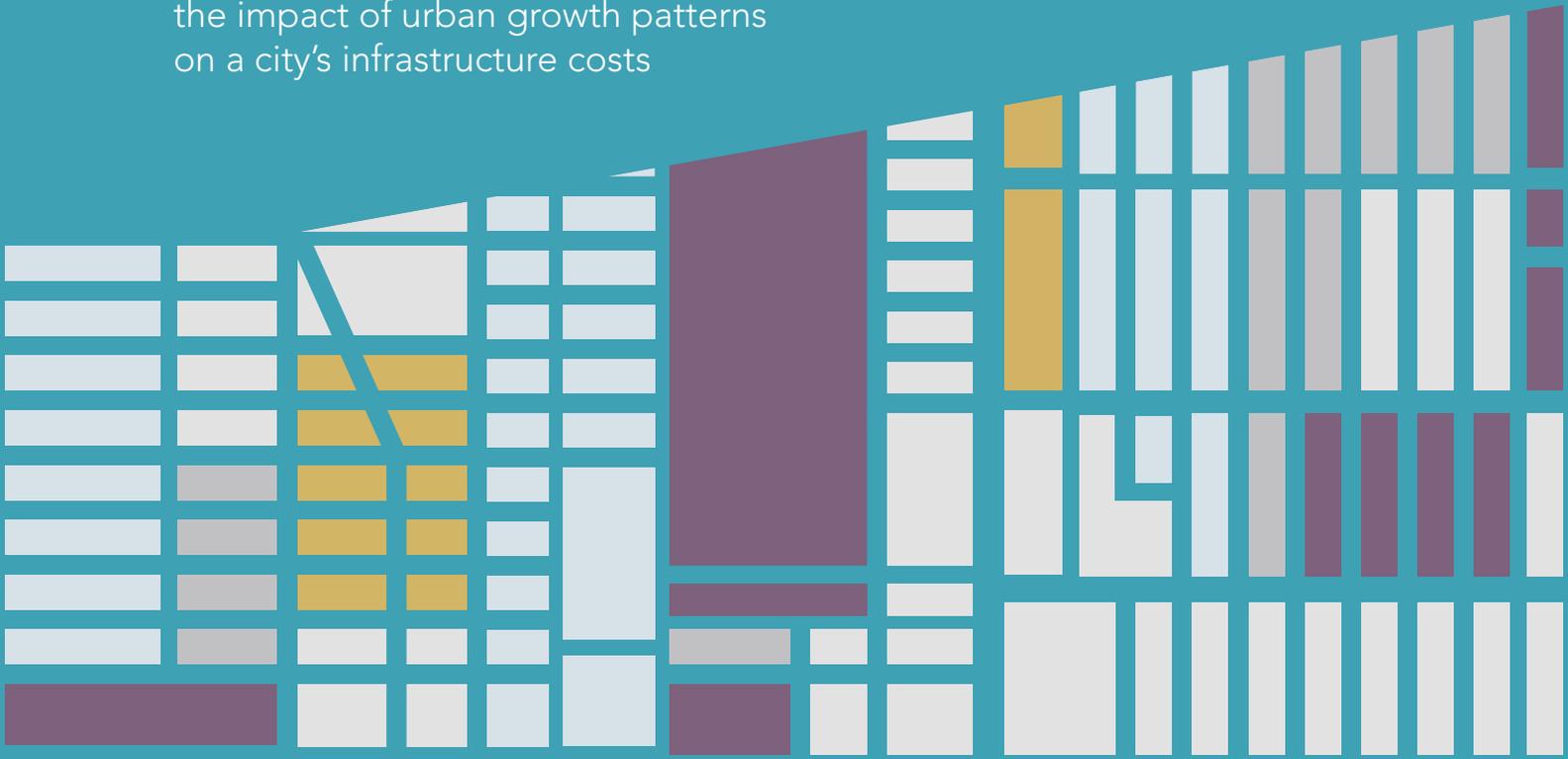


Infrastructure Costs and Urban Growth Management

A practical guide to understanding
the impact of urban growth patterns
on a city's infrastructure costs



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We would also like to acknowledge the two city project teams from Calgary and Los Cabos that led the planning processes used as the basis for this Guide. SCI commends their dedication to creating a more sustainable future for their cities.

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Sustainable Cities International September 2012

Designed by Elise Rocque of Rocque Creative
www.rocquecreative.com

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About Sustainable Cities International

Sustainable Cities International (SCI) is a registered charity and non-profit organization founded in 1993 and based in Vancouver Canada, one of the world's most liveable and sustainable cities. With core staff in Vancouver and a network of international associates, SCI works with cities around the world to bring about change towards urban sustainability. SCI focuses on building human capacity within cities so that innovation and change (required for sustainability) can occur. SCI provides guidance on a variety of projects from large-scale, city-wide planning strategies to small scale urban sustainability projects. Projects are designed in response to the needs of cities and in collaboration with the cities. A key focus of SCI's work is the design and implementation of participatory engagement processes as they relate to transportation, public infrastructure, local economic development and social and environmental projects.

SCI facilitates an international network of 40 cities, towns and metropolitan regions where innovative practices, experiences and ideas are generated and tested. SCI believes that cities are centres of knowledge creation and focuses on the exchange of ideas through peer to peer learning through forums, case studies and inter city mentoring initiatives.

SCI adopts a holistic approach to urban sustainability by addressing and integrating environmental, social and economic wellbeing into all of its work. SCI acknowledges that each city and region is unique and advocates that any approach to planning, policy development and action is adapted to meet local conditions.



About the Author

Patricia Gordon has over 25 years of experience of working on sustainability policy and programs in local government in Canada and the UK. From 2002 – 2009 she led two urban sustainability planning projects for the City of Calgary. The first was the imagineCALGARY project which engaged over 18,000 citizens and stakeholders to develop a vision for a sustainable future of the city. Pat then led a multidisciplinary team of planners and engineers on the Plan It Calgary project to align Calgary's land use and transportation plans with the vision of imagineCALGARY. Both projects won the Federation of Canadian Municipalities Sustainable Communities Award for planning.

Pat is currently the Director of the Sustainable Cities International Network, based in Vancouver. Pat has a BSc in Geography from the University of Calgary, Canada and an MSc in Earth Science and the Environment from Kingston University London, United Kingdom.



Message from Siemens Canada

What makes a city sustainable?

There is no easy—or single—answer to this question. Sustainable growth in cities depends on numerous interrelated elements, each of which plays an important role in both the short and long term.

Sustainable urban development poses enormous challenges to planners, managers, and participants in urban growth management. With over half of the world's population living in cities, it is vital that cities become more efficient in the use of funding and other resources. In many cases, however, the information and tools necessary to see real efficiency improvements are simply not available.

This is why Siemens Canada is proud to be a sponsor of this guide to infrastructure costs and urban growth management. We believe that Sustainable Cities International has created an important tool that provides real information on urban planning, and enables city planners and managers to realize major efficiency gains, which impact economic competitiveness.

At Siemens, one of our main areas of focus revolves around improving the long-term sustainability of urban centres. Not only is it good business, it makes us proud to contribute to the solutions that reduce the negative environmental impacts of cities around the world, while helping those same cities become more competitive.

We are all lucky to be living in such a great country. I hope that this guide helps city planners and managers to continue to improve cities across Canada, building better, more sustainable communities where we can all live, work, and play.

A handwritten signature in black ink, appearing to read 'R. Hardt'.

Robert Hardt, President and CEO
Siemens Canada Limited



Message from Sustainable Cities International

Sustainable Cities International works with cities around the globe, supporting them in their quest to create a more sustainable future for their citizens. While the search for solutions to their environmental and social issues continues, financial sustainability remains a critical concern for most cities as they face unprecedented rates of population growth. One important response to these challenges is to manage the physical growth of their cities in a manner that will enable cities to deliver the critical services of water, waste, education and transportation in the most cost effective way possible.

Sustainable Cities International (SCI) encourages 'city to city' learning as the most effective way for cities to gain the skills and knowledge that they require to address the challenges ahead. This Guide shares the experience of two cities, Calgary, Canada and Los Cabos, Mexico – members of the SCI Network. While they are worlds apart in climate and culture they share the challenge of managing rapid levels of population growth. Los Cabos, learning from Calgary's experience, carried out a study to understand the implications on the costs of infrastructure of different patterns of growth. This Guide will share the approaches of the two cities and the experiences of the practitioners that undertook the studies.

Sustainable Cities International is pleased to partner with Siemens, one of the world's most progressive and innovative companies. In the spirit of continued learning and exchange, we encourage users of this Guide to continue to share their experiences of making our cities more sustainable.

A handwritten signature in cursive script that reads "Jane McRae".

Jane McRae, CEO
Sustainable Cities International

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Chapter 1 | Introduction to the Guide

Infrastructure Costs & Urban Growth Management

As the world moves through its first 'urban century', with more people living in cities than in rural areas, city leaders are facing the challenges of rapid and, for some cities, unprecedented levels of growth. These challenges include environmental problems of air and water pollution and a decline in the functions of the natural systems on which the city relies. Unplanned or poorly planned growth also impacts the efficiency of the transportation system which in turn will impact the local economy as commercial vehicles and workers are caught in congested traffic. Meeting the infrastructure needs of a rapidly growing population can also overwhelm the capacity of a city to pay for new infrastructure while maintaining its existing stock of roads, water and wastewater facilities, schools and other public facilities and services. Tackling these problems begins with local governments and their stakeholders and citizens making better choices on growth management – how, when and where a city should grow.

In a well-managed city, growth management decisions occur on an ongoing basis and at various geographical scales - from the region to the city to the neighborhood. Good decision making demands up to date, accurate and comprehensible information at the most appropriate scale on a wide range of issues including demographics, housing, employment, environmental impacts and public infrastructure requirements.

URBAN GROWTH MANAGEMENT

Urban growth management is a set of techniques used by government to ensure that as the population of a city grows there are services available to meet their needs. Services can include: the protection of natural areas and provision of parks and open spaces, sufficient and affordable housing, adequate land for business and industry, and the delivery of utilities (water, waste water, roads, transit).

Techniques for growth management include fiscal tools such as taxes, levies and bonuses as well as the allocation of public funds for infrastructure. Regulatory tools include land use zoning and development controls. The application of growth management techniques are often governed by the development of a comprehensive or strategic plan for the city or region.

The process of decision making on urban growth (usually led by local public sector staff – planners or engineers) also requires engagement with a wide range of stakeholders. These include neighboring and other orders of government, citizens, community groups, non-governmental organizations, industries and business associations. The engagement process can be fraught with conflict between competing interests amongst stakeholders. For example, the goals and values of communities and citizens may conflict with those of the development and building industries. Successful growth management decisions, therefore, require robust stakeholder engagement informed by appropriate and accurate information that will lead to the best outcomes for the city and its citizens.

One critical piece of information is often missing from the growth management puzzle. That is the impact on infrastructure costs of urban growth patterns at the regional or city wide scale. This is due to a variety of reasons such as the complexity of working at this scale (the city or region) and the long timelines (many decades) that must be taken into account in this type of study. Currently, most cost of growth studies focus on shorter term projections (usually within a range of 10 years) that help a city to understand the impact on its near term capital and operating budgets for public infrastructure. However, new tools and approaches are available to practitioners that will enable them to inform decisions on the long term cost of growth. It is now possible to understand the impact of decisions from a much earlier point in the growth management process – enabling practitioners to reduce the costs of expensive infrastructure and, in some cases, even avoid having to build it from the outset.

THE BUSINESS CASE FOR COMPACT GROWTH

Studies undertaken by the cities of Calgary, Canada and Los Cabos, Mexico identified significant savings on infrastructure costs could be achieved through more compact growth. Savings of 33% and 38% were identified for the capital cost of roads, transit, water and other infrastructure for Calgary and Los Cabos. Savings on operational costs were 14% for Calgary and 60% Los Cabos.

The Business Case for Well Planned, Compact Urban Growth

Compact urban growth (alternatively referred to as smart or sustainable growth) is widely recognized as good public policy in cities around the world. It focuses on locating housing growth closer to job centers and public facilities that in turn can be more efficiently serviced by sustainable mobility options such as walking, cycling and transit. In a well-planned¹, compact city citizens can meet many of their needs without the requirement for extensive travel.

However, achieving compact growth is a challenge that requires change in policy (at all geographic scales) as well as in a city's operations and regulatory functions. Vested interests in the business community, civil society and even in municipalities themselves can present formidable obstacles to shifting the patterns of growth from sprawling to compact. A strong leverage point in favor of compact growth is to provide information on the related public infrastructure cost savings at the regional or city-wide scale for roads, transit, water and waste water and other public services and facilities. The savings can be significant for many cities.

This Guide will assist practitioners to undertake a study that provides current, local research on the fiscal savings that can be accrued on infrastructure costs when a city chooses to grow in a more compact form. With cities around the globe struggling with financial challenges in the face of high levels of growth this type of study is a valuable piece of the growth management puzzle.

¹ Some cities lack the capacity to undertake comprehensive planning or to enforce containment policies. In an effort to contain growth without adequate planning a city may fall victim to even more unsustainable patterns of growth. The Lincoln Land Institute of Land Policy, in its report *Making Room for a Planet of Cities* (2012) makes the case for a city to be well planned before it tackles compact growth. Each city must understand its unique planning and regulatory context before committing to any specific growth management strategies.

Who should use this Guide?

This Guide has been written for practitioners and participants involved in urban growth management decisions at the city-wide or regional scale. By their nature, these decisions are not simple or routine. Getting to a good decision involves a wide variety of actors and stakeholders from many different sectors and professions – engineers, architects, land use planners, politicians, land developers and home builders, citizens and stakeholders. One of the greatest challenges in this type of work is to provide a ‘level playing field’ where participants can get to a shared understanding of each other’s professional perspectives relative to the decision at hand. To facilitate this, the Guide provides links to books and papers that focus on foundational information (not highly technical) that will help to improve the process of good growth management decision making for a more diverse and better informed audience. The Guide is written in a non-technical style to encourage use by this diverse audience.

Guide users may be planners leading or participating in a city-wide or region-wide land use planning exercise. This may be a review of an existing development plan or the production of a new one. It may be used by professionals responsible for long range transportation planning. Or it may be used by asset managers or growth management teams that, while often working within a 10 year time horizon, are seeking to understand the impact of growth management decisions at a macro geographic scale and a longer time frame. In order to meet the needs of this range of applications The Guide provides a practical overview of the steps and inputs required to undertake a successful cost of growth study at the regional or city-wide scale.

Design of the Guide

This Guide will identify how cities can provide that missing piece of the growth management puzzle. Following on from making the case for smart growth in this chapter, Chapter 2 discusses various tools and approaches that are invaluable to the practitioner when working at the scale and scope of a city or a region.

Through two examples – the cities of Calgary, Canada and Los Cabos, Mexico – the Guide will provide a methodology to undertake a cost of growth study. Using the practical examples and experiences of the two cities, Chapters 3 and 4 provide a step-by-step guide to developing quantifiably based scenarios and studying the cost associated with different urban growth patterns.

Chapter 2 | Important Tools & Concepts

The Best Tools for the Best Decisions

Long range growth management decisions made at the city-wide or regional scale require a unique set of tools, practices and skills. A challenge for many practitioners is that these types of growth management decisions (long range, regional/city-wide) are often made at intervals of 5 to 10 years or in some cases with even less frequency. Practices and tools move on during the intervening time between these large scale planning exercises. Unless an agency is responsible for this type of work on a regular, ongoing basis and they are able to keep up to date with current practices and computer software investments, practitioners may attempt to use the same tools that they use for shorter term growth management decisions. With the advent of creative concepts such as scenario sets, sketch planning and backcasting, more accessible, cost effective approaches are available. Using inappropriate tools (e.g. tools for short range growth management) will likely result in little or no changes in a city's efforts to move towards more compact, sustainable forms of growth. The status quo (sprawling urban form) is likely to prevail when short term tools and practices are used for long term decision making.

The diagram below identifies the different tools and approaches used in long range and short range growth management.

	LONG RANGE GROWTH MANAGEMENT	SHORT RANGE GROWTH MANAGEMENT
GEOGRAPHICAL SCALE	City-wide or regional (the whole urban system)	Community or neighborhood
SCOPE OF CONTENT	Land use and transportation systems	Land use, transportation or other infrastructure
PLANNING HORIZON	Long term (30+ years)	Short term (5 – 15 years)
DECISION MAKING INTERVALS	5 – 10 years	1 – 5 years
TOOLS	Scenario sets, GIS or sketch planning, forecasting and backcasting	Transportation modelling, forecasting

Scenarios

Scenarios are tools that help groups to make better decisions about the future and they are the key tool available to practitioners in long range urban growth management planning. They assist with strategic thinking and option searches. Scenarios have been used in the military, the business sector and industry, and for the last several decades in land-use planning. Through the process of developing and analyzing a series of alternative views of the future (a scenario set), practitioners and stakeholders learn about the implications of the different choices that they can make. Learning is the key function of scenarios. In themselves, scenarios do not provide the answers, but they enable us to observe and understand the wide range of possibilities that interact to create our future. Scenarios are the tool of choice when dealing with high levels of complexity and uncertainty (prevailing conditions when planning the future of a city or region).

Scenarios for business applications are usually developed in a written format (narrative scenarios). Narrative scenarios may also be used to develop a vision for an organization, a town or a city. The key difference between a narrative scenario and land use scenario (as required for our purposes) is that the latter is represented in a spatial or geographical format (a map) – accompanied by a supporting narrative. They are usually ‘built’ on the outcome of a dialogue amongst stakeholders and practitioners about the future for their city.

FOUNDATIONAL READING MATERIALS ON SCENARIOS

FUTURES UNDER GLASS: A RECIPE FOR PEOPLE WHO HATE TO PREDICT

By John B Robinson

Futures, Vol. 22, No. 8. (October 1990), pp. 820-842

This article highlights the role of backcasting in scenario planning

THE USE OF SCENARIOS IN LAND-USE PLANNING

By W-N Xiang and K C Clarke

Environment and Planning B: Planning and Design volume 30, (2003), pp 885 – 909

THE ART OF THE LONG VIEW. PLANNING FOR THE FUTURE IN AN UNCERTAIN WORLD.

By Peter Schwartz

Bantam, Doubleday, Dell 1996

A seminal book covering the process of narrative scenario building as a tool for strategic planning and decision making in business

INTEGRATING LAND USE ISSUES INTO TRANSPORTATION PLANNING: SCENARIO PLANNING; A SUMMARY REPORT.

By Keith Bartholomew, 2006

(retrieved from the University of Utah, College of Architecture and Planning website)

http://faculty.arch.utah.edu/bartholomew/SP_SummaryRpt_Web.pdf

Participatory Engagement

“Scenarios are inherently participatory or they fail”. Schwartz 1996

Participatory engagement is not a new concept to most public sector practitioners who are required to engage on policy development. The process described in this Guide is no exception. In the past, scenario planning has often been viewed as the realm of the expert. This was likely due to the complexity of the tools (such as transportation models) used for this type of work. However, with the advent of newer sketch planning and GIS based tools public engagement in scenario planning is more common place. The success of the scenario process described in this Guide is dependent on good participatory engagement.

Participatory engagement is critical to the success of this type of public policy process for a variety of reasons. First, it will create a constituency of support for the work. Stakeholders that are informed and engaged will be likely to articulate their support to the elected officials that will be making the decisions. Secondly, participatory engagement results in a more rigorous outcome for the work. Cities are complex systems and no one project can examine all aspects of the urban system in depth. By engaging a wide range of stakeholders, representing all aspects of the system, the outcome will be based on the best knowledge and information available. The third reason to engage is to tap into the creative and innovative capacity of a diverse group of people who are interested in the future of their city. New ideas and solutions to problems can evolve through dialogue. Scenario planning is the ideal approach for this interactive engagement to occur.

Linking Land Use and Transportation

The form of a city's growth is the result of decisions taken by a multitude of actors in the urban system – home buyers, builders, developers, businesses and local governments. However, at the heart of shaping a city or region's urban form is the interdependent relationship between land use and transportation – two functions directly controlled or heavily influenced by local government. The nature of land development, its density and location influence travel patterns and, by creating greater access to land, the transportation system influences its use. Much of the other linear public infrastructure – water pipes, waste water – aligns itself with the transportation network. If the land use and transportation are not linked from planning, to policy making, to implementation, a city's smart growth objectives will be difficult to reach.

Accommodating the automobile in our cities, while providing increased freedom and accessibility for many people in the past, has had an adverse effect on the form of our cities as they have grown. Planning for the automobile has resulted in low density, sprawling communities (often on the periphery of the city) that have become reliant on the automobile for virtually all trips. By necessity a car is required to live in these areas of city as they cannot be effectively served by adequate levels of transit, walking or cycling. In turn, more cars create more traffic congestion – a root cause of poor air quality, increasing greenhouse gas emissions and the associated impacts on people's health and the economy as workers and commercial vehicles are stuck in traffic. Cars can be out of financial reach for people on limited incomes thus limiting their participation in economic activity as well as their access to goods and services. And servicing widely spread communities with public infrastructure (roads, transit, water and waste water etc.) is also more costly – as the distance increases, so do the capital and operating costs of the roads and pipes.

THE RELATIONSHIP BETWEEN LAND USE AND TRANSPORTATION

Land use and transportation are symbiotic: development density and location influence regional travel patterns, and, in turn, the degree of access provided by the transportation system can influence land use and development trends. Urban or community design can facilitate alternative travel modes. For example, a connected system of streets with higher residential densities and a mix of land uses can facilitate travel by foot, bicycle, and public transportation, in addition to automobile. Conversely, dispersed land development patterns may facilitate vehicular travel and reduce the viability of other travel modes.

Source: US Department of Transportation: The Transportation Planning Process Key Issues (no date)
www.planning.dot.gov

To achieve the goals of compact or smart growth, a city-wide or regional planning exercise must make a strong link between land use and transportation – preferably at all stages of planning and implementation. Although this is recognized as best practice, many municipalities or regional planning agencies struggle to adequately integrate land use and transportation into planning exercises due to jurisdictional issues. In some cases, transportation planning is performed by a regional transportation agency while land use decisions are taken at a more local level. Despite the direction by higher level government policy to ‘align’, the two functions struggle to effectively integrate. Integration requires that they are planned concurrently - with land use and transportation policy outcomes that have equal levels of influence in local growth management decisions. When undertaking this type of project every effort must be made to link land use and transportation – even across jurisdictional lines – throughout the planning and implementation phases of work.

Backcasting and Forecasting

We are all familiar with the concept of forecasting - a method of translating past and current trends into estimates of the future. On the daily news we hear economic forecasts for countries, quarterly business performance forecasts and, in the lead up to elections, political forecasts. Forecasters are often experts aided by complex computer models that can calculate many hundreds of thousands of data points and apply complex algorithms that represent facets of human behavior to the calculations. Thus the forecast becomes a powerful tool for predicting the future.



But what if the current trends are part of the problem? Sprawl is a perfect example of a current trend in urban growth that, if a forecasting methodology is applied, results in a prediction of more sprawl! As a tool for understanding what is possible in the future, forecasting alone will provide little divergence of perspective in a dialogue about the future of your city. So where does that leave practitioners who are working on long range urban planning initiatives?

In the 1980's Dr John Robinson, now a professor of geography at The University of British Columbia in Canada, introduced the concept of 'backcasting' to long range future studies. He credits the American scientist Amory Lovins with devising the concept. Backcasting starts by defining a desired future (often called a vision) and then assessing what is required to get to that future. When used as part of a scenario planning exercising (see Chapter 3: Working with Scenario Sets), backcasting enables practitioners and their stakeholders to introduce creative, new ideas – opening up the dialogue to a future that we can create versus one that is purely predictive based on past trends and behaviors. This is a critical concept for practitioners to understand, particularly when working on sustainable development – which often requires a change of direction from the status quo or business as usual. This does not preclude us from using forecasting tools but it is important to know how the two approaches can complement each other. Both forecasting and backcasting play a role in long range growth management planning and a successful practitioner will recognize when and how to deploy each of the methodologies.

Backcasting is a useful approach when;

- The problem is complex, affecting many sectors and levels of society;
- There is a need for major change i.e. when incremental changes will not be sufficient;
- Dominant trends are part of the problem – these trends are often the cornerstones of forecasts;
- The problem to a great extent is a matter of externalities, which the market cannot treat satisfactorily;
- When the time horizon is long enough to allow considerable scope for deliberate change².

² Dreborg, Karl H.

Futures, Vol 28, No 9. pp 813 - 828. 1996

FOUNDATIONAL READING ON BACKCASTING

FUTURES UNDER GLASS: A RECIPE FOR PEOPLE WHO HATE TO PREDICT

By John B Robinson

Futures, Vol. 22, No. 8. (October 1990), pp. 820-842

Sketch Planning & Transportation Modelling

Practitioners should also be aware of the different roles of sketch planning and transportation modelling in long range growth management planning. Although transportation models are not used in all cities, they are prevalent planning tools in larger Canadian and US cities and metropolitan areas. However, long range growth management decisions are taken at a scope, scale and time horizon (many decades) that cannot be accomplished using only a traditional transportation model. Although a few agencies have adapted their models for this type of work, simpler more cost effective options are available to practitioners.

Sketch planning (sometimes incorrectly referred to as sketch modelling) enables practitioners to undertake relatively quick, order-of-magnitude analysis on different urban futures. This is a useful attribute when working closely with a wide range of stakeholders over a short period of time as options can be discussed and generated in a very short period of time (in the case of some GIS based tools within the span of a short workshop session). Transportation models, on the other hand, require expert set up, extensive data input and analysis, are more costly and take much longer to generate an output which is often too detailed for the purposes of long range growth planning.

Transportation models are sophisticated computer simulation tools designed to imitate the travel patterns of a transportation system over time in order to predict system performance. In essence they provide forecasts of travel behavior. Model 'runs' can be viewed as experiments where modelers can test various assumptions associated with changes in the system – for example a new bypass road may be proposed for a city and the impacts on local traffic patterns want to be understood. Transportation models can work at various levels of detail – from the microscopic (individual vehicles in a local setting) to the macroscopic (general traffic flows across a city).

Transportation models have limitations within the context of long range growth management decisions. Their complexity is both their strength and their weakness in that they are powerful forecasting tools that can inadvertently 'become the decision' instead of 'informing the decision'. Sometimes referred to as a 'black box', transportation models are difficult for non-experts to understand and therefore, it is difficult to understand or challenge the outputs. Their powerful, short term predictive capacity caze early stages of growth management decision making addressed by this Guide. (see Chapter 3 for a discussion on 'business as usual' scenarios).

A model 'run' can require the input of several thousand data points and the output can result in hundreds of thousands of data points that must be managed and analyzed. And, despite their sophistication, many transportation models are not designed to respond to the needs of smart growth. They often cannot effectively incorporate the critical relationship of transportation and land use. Some models cannot incorporate transit options and they are often unable to consider finer scaled mobility options such as pedestrian and cycling movements which are at the heart of smart growth policy choices. For the purposes of the type of work promoted in this Guide the best timeframe for a transportation model to be used is following a sketch planning exercise that will narrow the scope of the options to be analyzed.

Sketch planning tools (sometimes referred to incorrectly as models) are used to produce estimates of transportation and land use demand and impacts. They can be spreadsheet-based or GIS-based and allow for the rapid input of land use and transportation options as part of a scenario process which is the focus of the next chapter. Sketch planning tools can range from simple spreadsheets to more complex GIS based computer tools, often with a graphical interface that enables a 'just in time' approach to reviewing scenarios with stakeholders.

FOUNDATIONAL READING ON SKETCH PLANNING AND TRANSPORTATION/LAND USE MODELLING

INSIDE THE BLACKBOX: MAKING TRANSPORTATION MODELS WORK FOR LIVABLE COMMUNITIES

By Edward Beimborn, Rob Kennedy, William Schaefer,

Citizens for a Better Environment, and Environmental Defense Fund. Milwaukee, WI: Citizens for a Better Environment, 1996

(retrieved from the University of Wisconsin – Milwaukee, Centre for Urban Transportation Studies website)

<http://www4.uwm.edu/cuts/blackbox/blackbox.pdf>

SKETCH PLANNING

An overview of the role of sketch planning tools (although the focus of many of the tools listed here is on evaluating climate change there are some tools listed that enable infrastructure cost outputs as well): (Retrieved from The Travel Forecasting Resource website)

http://www.tfresource.org/Topics/Model_Application/Climate_Change_and_Green_House_Gas/Sketch_Planning_Tools_-_Climate_Change.aspx

Chapter 3 | Working with Scenario Sets

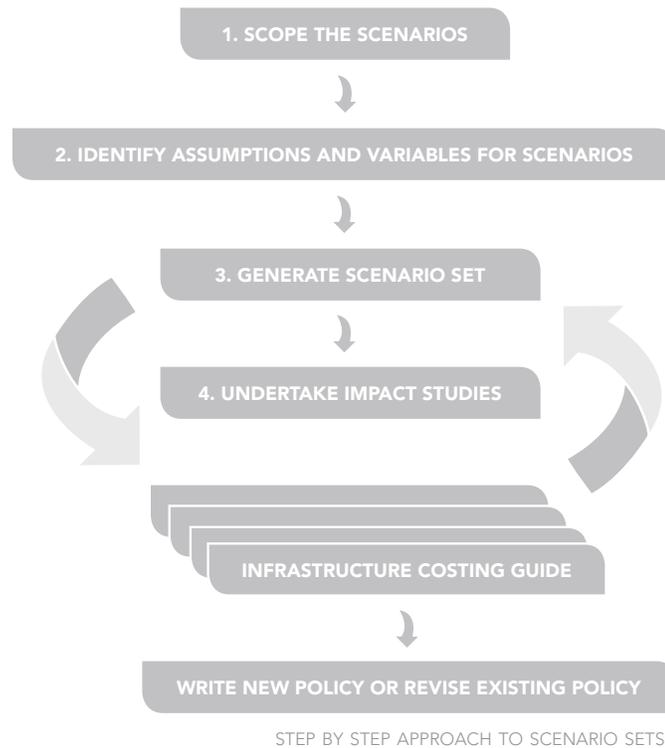
Introduction

This chapter will deal with creating scenario sets. As we explore the ‘how’ of scenario building it becomes apparent that the process is a calculated combination of both art and science – qualitative and quantitative approaches to learning and decision making are involved. The methodology used in this Guide has been adapted from the approach described by Robinson³ an advocate of the use of backcasting in scenario development. Adaptations to the methodology reflect the experience of two cities - Calgary, Canada and Los Cabos, Mexico – each having completed a spatial scenario process and infrastructure costing study as part of their long range growth management planning process.

Developing spatial scenario sets is common practice in long range urban planning and growth management although the approaches can vary considerably. In a US study released in 2006, many land use and transportation planning projects continued to use transportation forecast models as the primary tool for developing scenarios⁴ (this is not surprising as many regional planning agencies in the US have transportation planning mandates). For reasons discussed in the previous chapter, the predominance of forecasting techniques in scenario development is likely to result in limited shifts towards smart growth or a compact urban form. The study reported, however, a few agencies were employing a sketch modelling approach for scenario development before using a transportation model for impact analysis. This Guide proposes that practitioners develop land use and transportation scenarios through a sketch planning process incorporating both forecasting and backcasting techniques. This chapter provides a step by step approach to developing a scenario set.

³ Futures Under Glass: A recipe for people who hate to predict
Robinson, John 1990. Futures Vol 22 No 8 (October 1990) pp 820- 842

⁴ Integrating Land Use Issues into Transportation Planning: Scenario Planning.
Summary Report Bartholomew, Keith 2006. College of Architecture and Planning
University of Utah. Bartholomew found that over 50% of projects in his survey used
a travel forecasting model



Step 1: Scope the Scenarios

The first step is to scope your scenario process. This will include the purpose and extent of the work to be undertaken. This type of study is broad, complex and engages multiple stakeholders who can present a communications problem for practitioners - developing and documenting the scope is the first step in managing that. When working with stakeholders who are unaccustomed to the concepts of scenarios the scoping document is a useful tool for communication. For the purposes of a long range growth management scenario a number of components are useful to include in the scope including:

1.1 Purpose of the scenarios

- a) City vision
- b) Principles for land use and transportation
- c) Areas of inquiry

1.2 Scope of the scenarios

- a) Geographical (spatial) area and political jurisdictions
- b) Time horizon
- c) Number of scenarios
- d) Names of scenarios

Your organization may already have some of these elements in place – particularly if you are undertaking a review of an existing plan or aiming to undertake the cost analysis once a plan is already complete. If that is the case you will have to assess what you have and decide if it is sufficient to proceed to the scenario work.

1.1 Purpose of the scenarios

1.1a City vision

Long range urban growth management decisions benefit from a clear vision or direction that has the commitment of key stakeholders and even the wider community. For the purposes of urban growth management, the vision describes a desired future. With the introduction of the concept of sustainable development, many cities have undertaken some sort of participatory visioning exercise with their citizens. These are usually broad in scope (covering all of the social, environmental and economic systems of the city), long range in perspective and describe a positive and sustainable future for the city and its inhabitants. To achieve this desired future the physical form of the city is often required to change from sprawl to more compact in order to improve sustainability outcomes.

In the case of Calgary a long range visioning and planning exercise was undertaken called imagineCALGARY in which over 18000 citizens expressed their aspirations for the future of the city. The Calgary vision included a vision statement as well as series of goals, targets and strategies to reach the vision. This was a separate exercise completed in advance of the land use and transportation project called Plan It Calgary, and ran over a two year period. In Los Cabos, the vision was tied directly into the process of updating the Plan de Desarrollo Urbano 2040 (Urban Development Plan). At the outset of their process they developed a vision through stakeholder dialogue that engaged 180 stakeholders and citizens.

1.1b Principles for Land Use and Transportation

The sustainability vision for a city is likely to incorporate many topics that are not directly relevant to the land use and transportation systems that are the focus of this study. For example a sustainability vision is likely to include goals on improving educational attainment but the land use and transportation system does not directly influence them. It is necessary, therefore to deconstruct the vision and identify which elements of the vision are directly relevant to your work. This is a worthwhile exercise that helps to refine the focus of the work at hand. In the case of Calgary, the output of this process resulted in a set of principles (Calgary's Sustainability Principles for Land Use and Transportation). Principles serve a variety of purposes and are an essential tool for the practitioner. Sometimes criticized for being too generic, the role of principles is not to provide

detail but to provide the basis for an agreement on the general direction of the work. The principles also help with ongoing scope management (e.g. if additional work is requested or the direction of the work is challenged the principles serve as an anchor point for the discussions). Principles are a useful communications tool and throughout the project can act as the 'guardrails' to keep the project within the agreed scope. They can emphasize the need to link land use and transportation. And, for projects that require ongoing political direction or decision making, principles can form the basis of an agreement with elected officials on the direction and scope of the work. Calgary's principles also acted as interim policy direction for ongoing planning and development work that occurred during the two year project.

Smart growth principles (or other sustainable growth principles) exist for many jurisdictions and may already be the approved direction for growth management in your city or region. When developing principles, it is helpful to review different sets of principles from other jurisdictions and to consider what would work in your local context. If the principles are aligned with a city vision that is widely supported by stakeholders and citizens this will give them more credibility. The Calgary and Los Cabos principles are show in the boxes below.

1.1c Identify the areas of inquiry

SUSTAINABILITY PRINCIPLES FOR THE CALGARY INTEGRATED LAND USE AND MOBILITY PLAN

1. Create walkable environments
2. Foster distinctive, attractive communities with a strong sense of place
3. Provide a variety of transportation options
4. Preserve open space, agricultural land, natural beauty and critical environmental areas
5. Mix land uses
6. Strategically direct and manage redevelopment opportunities within existing areas
7. Support compact development
8. Connect people, goods and services locally, regionally and globally
9. Provide transportation services in a safe, effective, affordable and efficient manner that ensures reasonable accessibility to all areas of the city for all citizens
10. Provide transportation services in a safe, effective, affordable and efficient manner that ensures reasonable accessibility to all areas of the city for all citizens
11. Utilize green infrastructure and buildings

SUSTAINABILITY PRINCIPLES FOR LOS CABOS PDU 2040

1. Workplaces near our homes
2. Accessible corridors with mixed use
3. Public transport, pedestrian and bike path networks
4. Near and accessible public spaces
5. Modular infrastructure
6. Alternative energy
7. Diversity of housing types
8. Densification

The key purpose of undertaking a scenario process is to make decisions; therefore, it is beneficial at the outset to identify the decision(s) to be made. Calgary framed these as areas of inquiry. This seems like an obvious step however it can be overlooked and it plays a role in clarifying your purpose, particularly with stakeholders. The Calgary project team identified a set of four questions that it would be seeking to answer through its scenario sets. The first statement outlines assumptions around the independent variables of population and employment (identifying these variables is covered in greater

CALGARY'S AREAS OF INQUIRY

Assuming a growth forecast of 1.2 million people and 600,000 jobs by the year 2060 for the city of Calgary...

- Where will people live?
- Where will they work?
- How will they travel to meet their needs?
- What are the social, economic and environmental implications or consequences of these choices?

detail in Step 2). The four questions are the essence of what the scenario process will explore; how housing and work places will be distributed across the city and how people will travel. The last question emphasizes the intent of the scenario process to explore the implications of the difference choices or options that can be considered with the first three questions. Difference distributions of housing and workplaces and different choices of travel will have different social, economic and environmental implications. Some will be more sustainable than others.

1.2 Scope of the scenarios

1.2a. Geographical and political boundaries

The geographical and political boundaries to be considered by the scenarios are not always easy to define. From a systems perspective, the scenarios should encompass the functions of the land use and transportation system in its entirety (this is usually a regional scale). Transportation systems typically function across multiple jurisdictions with roads and rails spanning many political boundaries. However, it is at the local scale that most land use decisions are made. This presents a challenge to selecting the spatial scope of the scenarios. Recognizing that the scenario process is primarily about policy setting and political decision making, Robinson (1996, page 826) states that 'the spatial scope of the analysis should be chosen to reflect the possibility of meaningful political or institutional change and behavior.' For practitioners within an agency or jurisdiction this may mean a collaborative approach is required to enable multiple jurisdictions to share in the learning and policy outcomes of the process.

The Calgary and Los Cabos case studies are, in this respect, unusual. Both cities represent a singular political boundary that aligns well with the functioning of the transportation system and contains the majority of the land use decision making function. Calgary does work within a regional context however at the time of the Plan It Calgary project it was decided to proceed with the scenarios using the city's geographical and political boundaries to define the extent of the scenario set. For both cities their unitary status made the selection of project boundaries easier and the decision making process was more streamlined than may be possible with multiple jurisdictions.

1.2b Time horizon

Throughout the Guide the emphasis has been on the need for this kind of study to be long range in nature. But what does long range mean? From a political perspective it is challenging for policy to go even 25 – 30 years into the future - most political mandates and priorities are of a much shorter nature. As outlined in the previous chapter, participatory engagement is critical in order to overcome this problem. Creating a constituency of support from local stakeholders and citizens will ensure ongoing support for policy even through the change of political mandates.

Calgary and Los Cabos are both cities that have statutory urban plans containing policy with 30 year time horizons. Each city, however, took a different approach to

setting a time horizon for their scenarios

There are valid reasons for taking a longer perspective within the scenario process than the 30 year horizon of statutory plans. Given the long life cycle of city infrastructure, a time horizon of 50 – 100 years is a frame within which considerable change can be achieved. The backcasting methodology is well suited to these long range exercises as forecasting becomes less rigorous over a longer period of time. The City of Calgary used a time horizon of 60 years to develop the scenarios for their integrated land use and transportation planning process. The Calgary team positioned the scenarios as opportunities for learning and regularly reminded stakeholders and decision makers that the spatial scenarios generated were not intended to be the final products. Although rational, it proved difficult for stakeholders not to view the spatial scenarios as the final product due partly to the fact that spatial scenarios are created and reviewed as maps and maps are normally considered concrete representations of what is or will occur on the surface of an area. Once a favorable 60 year scenario was developed (through a combination of backcasting and forecasting methodologies) Calgary then backcasted to develop the 30 year policy plan.

Los Cabos used a 30 year time horizon for their stakeholder visioning and for their scenarios and did not report any concerns related to this time frame.

Many scenario practitioners recommend that the time frames of the scenarios should not be formulated too precisely and used in a hypothetical sense only⁵. This would further emphasize that the scenarios are for learning only and do not represent the final product. Others have found that a timeframe may be helpful to enable stakeholders to understand the proposed rate of change.

1.2c Number of scenarios

Choosing how many scenarios to use is the next challenge. There is no right or wrong number of scenarios, however, when selecting an approach, there are some key points to understand about how people make choices. Scenario sets of the type we are proposing here will usually be comprised of 2 to 3 scenarios⁶, each one testing different assumptions and their acceptability with stakeholders. The scenarios used in Calgary and Los Cabos were single themed – examining the implications of different distributions of population and job intensities accompanied by different travel options.

Each city created a status quo or base case scenario that represented an approach to development that continued current trends. And each city created a scenario aligned with the vision that had been developed through stakeholder engagement. As an additional iteration, Calgary also developed a third scenario that represented an option that fell between the status quo and the vision.

⁵ The Use of Scenarios in Land-Use Planning W-N Xiang and K C Clarke.
Environment and Planning B: Planning and Design volume 30, (2003), pp 885 – 909

⁶ *ibid* page 898

Experts are divided on the benefits of two or three scenarios and it has to do with how people make choices. The benefit of a three scenario set is that it presents a wider range of futures (than the 2 scenario set) that are adequate in number but not overwhelming for stakeholders to understand. However, people have an inbuilt propensity to 'pick' the middle scenario resulting in an approach similar to a single 'forecast' thus negating the very purpose of the scenario set which is to explore a broader set of alternatives⁷.

Proponents of two scenarios claim that this approach works well with people's naturally optimistic and pessimistic perspectives on risk thus confronting stakeholders with their best and worst case views of the future. Calgary started with two scenarios, however, this resulted in elements amongst the stakeholders 'taking sides' and the two sides developed a defensive stance on the scenario that they felt represented their needs - the land developers and home builders on one side and environmental and sustainability proponents on the other. Developing a third scenario allowed the two sides to find some common ground although it was difficult to move them out of their entrenched perspectives.

1.2d Naming the Scenarios

When naming the scenarios it is important that the name not imply a positive or negative image that may unduly influence people's perspective. For example, when naming the scenario that depicts the status quo avoid the use of the term 'sprawl' and use a less biased term such as 'business as usual' or 'trend'. Given that we are taking a single themed approach (density) the terms low, medium and high may suffice however these terms are unlikely to arouse people's imaginations and creative thinking skills – a core intent of the scenario process.

In our two case studies Calgary called their status quo scenario 'business as usual' and Los Cabos called theirs 'tendencial' which in Spanish translates to trend. Calgary called the scenario related to their vision the 'compact' scenario and Los Cabos called theirs the 'vision' scenario. In an effort not to unduly influence people's perspectives Calgary's third scenario was called the 'hybrid' scenario.

Step 2: Identify Assumptions and Variables for the Scenario Set

The purpose of this step is to create quantifiable information that will be used to measure and map the scenario set. This is often the most time intensive step of scenario development as a considerable amount of data is generated, discussed, considered and discarded or recorded.

⁷ Ibid page 899

2.1 Translate the vision into quantitative targets

The vision and principles are usually expressed in qualitative formats and the objective here is to translate them into quantitative targets for use in the scenario sets. The translation requires access to data that may be difficult to obtain. In some cases, data may be held by other agencies or other orders of government therefore collaboration will be required in order to access the data. Engaging the staff of these agencies at an early stage in the process will help them to understand what data is required and why. Their involvement early on will likely result in a more cooperative attitude towards making data available. When developing its vision, Los Cabos engaged departmental directors from the municipal, state and federal governments as well as representatives from non governmental organizations that had relevant data. In addition to easing the flow of data, the input from these expert stakeholders added value to the planning work.

Creating an organizational hierarchy may help to manage the large amount of quantitative and qualitative information. Calgary developed an extensive spreadsheet as the team parsed through the vision, principles, goals, objectives, and identified the data most relevant to their needs and set targets that would provide direction for the scenario process. Robinson reminds us that the best targets are readily measured with available data⁸. The Calgary team called their organizational hierarchy a decision support framework. The framework also included 'placeholders' for strategies and actions (to be defined as part of the policy development stage of the work). And the data collected for the framework formed the basis of the monitoring and measuring system that was put in place for the long range plan (Calgary's Municipal Development Plan).



⁸ Futures under glass: A recipe for people who hate to predict
John B Robinson *Futures*, Vol. 22, No. 8. (October 1990), pp. 820-842

2.21 Identify assumptions for the scenario set

The assumptions provide the setting within which the scenarios are developed but are outside the scope of the actual scenarios. For example, the rate of economic growth is not under the direct influence of a land use and transportation plan. Economic growth acts upon the land use and transportation system therefore the rate of economic growth provides the context for the scenario process. We will express the context variables as a fixed assumption e.g. By the year 2060 Calgary will have an additional 1.2 million people and 600,000 jobs. In essence, they are the fixed frame that the scenarios occur within.

For the purposes of land use and transportation planning the context variables are usually population and employment forecasts. These forecasts help planners decide the future demand for housing and employment sites, roads and transit services, water and waste water facilities, parks and other infrastructure. Demographic and economic forecasting is highly specialized work undertaken by skilled experts. In Calgary the project team hired an independent consultant (who analyzed federal census data). The Los Cabos team used data supplied by the National Population Commission (part of the Mexican Federal Government). Some bigger cities have their own 'in house' forecasting teams. Calgary's population target was 1.2 million additional people – more than double their current population. Los Cabos' target also represented a doubling of their population, from almost 300,000 to more than 600,000 indicating even greater growth pressures than those of Calgary.

In addition to the population forecast, an economic forecast is also important. Understanding how many and what types of jobs are forecast for the future of the city enables practitioners to identify and distribute enough land and supporting infrastructure for offices, industries and other economic activities.

Demographic forecasts often include additional information on age, gender, immigration and out migration and other population based analysis. Economic forecasts may include numbers and types (office, retail etc.) of jobs as well as sector analysis. Some cities may wish to change the current trend (remember that these forecasts are based on current trends). For example, it may be desirable to increase the jobs/housing balance and this can be explored through the scenario process.

2.22 Identify Variables for the Scenario Set

Given that our stated aim is to analyze different patterns of urban growth the most common targets and indicators will relate to: the location and density of growth, its homogeneity or heterogeneity (mix) as well as different elements of the transportation system. These can be expressed by the Five D's of density, diversity, design, destination accessibility and distance to transit. These characteristics of the built environment have been identified as having the greatest impact on creating a more compact urban form⁹.

THE 5 D'S

1. **Density** - how many residents and/or employees are located within a unit of area
2. **Diversity** - the degree to which different land uses are located within close proximity of each other, reducing the need to travel near and accessible public spaces
3. **Design** - a range of measures which describe how conducive an area is to walking, variously described by the quality of footpaths and road crossings, the connectivity of the road network, and the quality of the pedestrian environment (noise, safety, visual interest, weather protection)
4. **Destination accessibility** - measures that reflect the proximity or ease of access to regional trip opportunities such as employment, which can be measured by distance or time
5. **Distance to transit** - how far an area is from the nearest public transport stop or station

Adapted from Reid and Cervero 2010

⁹ Travel and the Built Environment

Ewing, Reid and Cervero, Robert (2010) Journal of the American Planning Association, 76: 3, 265 — 294.

The following table provides examples of how each of the 5D's can be measured. As you assess the availability of data it is important to then identify the variables in today's measure as a baseline and to set targets for the business as usual and vision scenarios.

THE FIVE D'S	INDICATORS (SOME EXAMPLES)	TODAY'S BASELINE	BUSINESS AS USUAL TARGET	VISION TARGET
DENSITY	<ul style="list-style-type: none"> • Residential density • Household density • Employment density • Activity intensity (population + jobs) 			
DIVERSITY	<ul style="list-style-type: none"> • Jobs/housing balance • Land use diversity index • Residential diversity index 			
DESIGN	<ul style="list-style-type: none"> • Motorized and non-motorized route connectivity index • Number of intersections per square kilometer or mile • Average block size • Proportion of four way intersections • Sidewalk coverage • Numbers of pedestrian crossings • Intersection density • Ratio of expressways to arterials 			
DESTINATION ACCESSIBILITY	<ul style="list-style-type: none"> • Jobs accessibility by auto • Jobs accessibility by transit 			
DISTANCE TO TRANSIT	<ul style="list-style-type: none"> • Jobs or population within walking distance of transit 			

Calgary's key measures and targets were published in their final land use and transportation plans and can be found on the City's website.

The scale for land use mapping needs to provide sufficient detail to understand the layout of transportation and supporting infrastructure from a city-wide perspective. This is typically less detail than a neighborhood or community plan, but will vary depending on the size of the city or region being studied. In Los Cabos, land uses were distributed using 1 hectare-square elements (residential, open space, etc.). In Calgary, suburban land uses were distributed using 1-mile square shapes (given the homogenous nature of most suburban developments), while redevelopments were mapped using a more refined scale similar to Los Cabos (due to the variety in land uses for these areas).

Setting the vision targets can be challenging, particularly if a substantial degree of change is required to meet the goals. Here, benchmarking from other cities can help. For example, meeting a density target that is much higher than current density levels will likely require the introduction of new housing types that may not be present in the city today, leaving stakeholders and participants uncertain about the implications of moving to higher density levels. One way to overcome this is to provide examples of density in the form of pictures from other cities. Thus benchmarking can include a qualitative (picture) element and a quantitative (measure) element.

Other graphic tools may also help to convey the character of different options for example, new types of transportation such as bus rapid transit or light rail (to support the increases in density) may be considered and pictures of these options will prove useful in conveying these concepts. Calgary generated a series of 'time lapse' pictures of a street to show how improvements of walking, cycling and transit options would coincide with increases in density. (see diagram below) This also helps to show that change will be incremental and may ease the anxiety of some stakeholders that is associated with change.

Time lapse picture sequence of land use and transportation change in a corridor

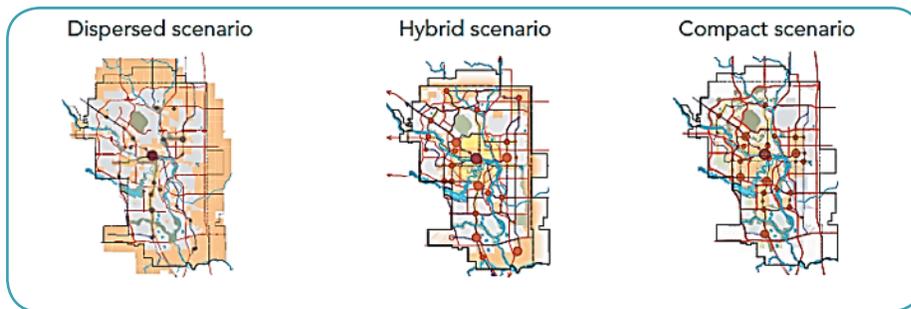
Source: The City of Calgary



Step 3: Generate the scenarios

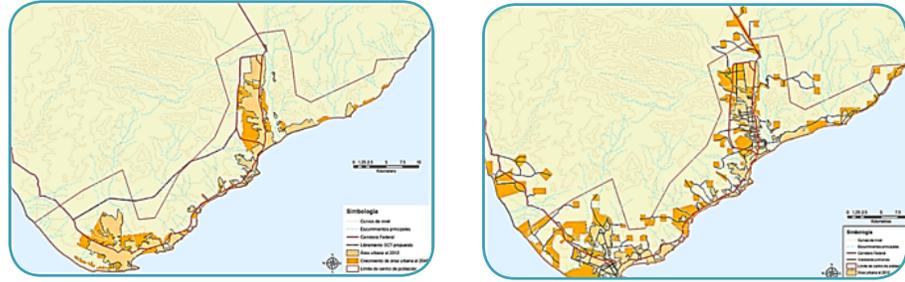
This step is dependent on the tools you have available for the generation of the scenarios such as a transportation model and/or sketch planning tools (discussed in Chapter 2). Unless the transportation model has been adapted for this type of long range planning its best application is to provide the basis for a business as usual scenario due to its strong predictive capacity.

Calgary developed 3 scenarios. Its business as usual scenario, entitled the Dispersed Scenario, was generated through the City's transportation model. The model outputs had to be aligned with a sketch planning process (used for the other two scenarios) in order to have consistent and comparable measures between the scenarios. The vision scenario or Compact Scenario was developed through a backcasting process using sketch planning tools that included both spreadsheets and GIS tools. The third scenario, the Hybrid Scenario, was also developed using a sketch planning approach.



Calgary's three scenarios

Los Cabos developed two scenarios, both using sketch planning and GIS tools. The business as usual scenario was called the Escenario Tendencial (Trend Scenario) and was achieved through forecasting directly from a current baseline, assuming little or no changes in the variables. The Escenario Visión (Vision Scenario) was backcasted from a visioning process undertaken with stakeholders.



Los Cabos' two scenarios

It is important to present the scenario information in a user friendly way that has meaning for stakeholders and participants in the process. Considerable amounts of data are generated through the development of the scenarios. The maps and any supporting narrative or numbers should be presented in as simple a format as possible without losing their meaning. Both Calgary and Los Cabos presented the scenario map and a short narrative with some quantitative information.

Step 4: Undertake Scenario Analysis (Impact Studies)

A range of studies examining the impact of the scenarios is possible once the scenario sets and supporting data have been generated. In collaboration with consultants as well as working 'in house', The City of Calgary undertook studies on topics of local significance including: housing affordability, transportation system connectivity, health and the cost of infrastructure. These can be found at The City of Calgary website www.calgary.ca/planit. The study entitled The Implications of Alternative Growth Patterns on Infrastructure Costs forms the basis of the methodology described in the next chapter.

Chapter 4 | Undertaking a Cost of Growth Study

Introduction

The previous chapter covered the methodology for developing a scenario set that will provide the baseline for undertaking a cost of growth study. Once the scenarios have been mapped and the data has been generated, the cost of growth study is a relatively straightforward exercise that utilizes a simple formula:

$$\text{infrastructure measure} \times \text{unit costs} = \text{total costs}$$

Although the study is presented as the final step of the process outlined in this Guide it is helpful to have spent time earlier in the process to consider the types of infrastructure you will study. This will allow you to engage the owners and operators of the infrastructure systems in the wider dialogue about the future of the city, its growth and urban form. Stakeholders who are well engaged and informed are more likely to make information available.

This chapter will be presented as a series of questions and answers incorporated into four steps:

1. Identify infrastructure for the study
2. Measure the infrastructure
3. Identify and apply unit costs
4. Report the results

Identify infrastructure for the study

Q. If we have generated more than two scenarios which ones should we use for the study?

A. Calgary produced three scenarios and undertook the study on their business as usual scenario and their hybrid scenario. The vision or compact scenario was considered by some stakeholders to have pushed the intensification of population too far and to include it in the cost study would have resulted in the risk of the study being dismissed by some key stakeholders that were adamantly opposed to that scenario. Los Cabos produced two scenarios and used those for the infrastructure cost analysis and have not reported a concern with this approach.

Q. What infrastructure should be included in the study?

A. Public infrastructure can include a wide range of facilities, public safety services, buildings, open spaces and, transportation and utility services (above and below ground). Identifying which infrastructure to include in your cost of growth study requires some research. This is because some forms of infrastructure are impacted by the growth of the urban form while others are impacted by the growth of the population. While the distinction between the two types of infrastructure is not absolute this is an important concept to understand before proceeding. Identifying the infrastructure impacted by the physical growth of the city is the first step in this type of study.

The most obvious types of infrastructure to include in this category are those that are linear in nature – roads, transit services, water and waste water distribution and collection pipes, and electrical distribution lines. As a city expands and consumes more land, linear infrastructure follows in order to service the new areas of growth. There are also some services, such as fire departments, that have to provide more facilities (fire stations) as the city grows in physical size. Calgary's fire department has a set time (in minutes) within which they were expected to respond to a fire. As the city spread, more fire stations were required to keep the trucks and firefighters within that response time. Calgary's schools were impacted similarly as they had a cap on the distance children should travel to school after which they school board had to supply a school bus service at an additional cost to the system.

There are some forms of public infrastructure whose growth correlates to the growth in the population and the urban form has less impact on their need to provide additional facilities. For example, water and wastewater treatment facilities increase their capacity in response to population, not to the urban form. But their distribution pipes respond more to the urban form. Another example is Calgary's police service which operates on an officer per capita approach for their service. As the population grows, more police officers are required but this does not necessarily require providing new facilities in the new areas of growth.

Calgary included the following infrastructure in their analysis:

- Roads (capital and operating)
- Transit (capital and operating)
- Water and wastewater (capital and operating)
- Fire stations (capital and operating)
- Recreation centers (capital only)
- Schools (capital only)
- Parks (operating only)

Los Cabos included the following infrastructure in their analysis:

- Roads (capital and operating)
- Transit (capital)
- Water (capital)
- Sewage (capital)
- Electricity (capital)
- Street Lights (capital and operating)
- Education (capital)
- Urban services (Fire and police)
- Health (capital)
- Recreation (capital and operating)

Q. Do I include capital and/or operating costs in the study?

A. You can include both the capital costs (the costs of construction) and the operating costs (the costs of maintaining and operating) of the infrastructure if the data can be obtained. The capital costs are the primary consideration and the savings can be significant – particularly on transportation and water related services. In Calgary these two categories of infrastructure accounted for 90% or \$10 billion of the savings identified.

It is also worthwhile including operating costs in the study. However the data for these costs may be more difficult to obtain. The impact on operating costs is similar to the capital costs, particularly with the linear infrastructure. Each additional kilometer of road or pipe adds additional maintenance costs as does each new facility. Calgary's operating costs were 14% less in the scenario with more compact urban form.

It is worth considering the subject of 'who pays' at this point. Capital expenditures can often come from other orders of government such as the province or state or even federal or national authorities. Operating expenditures fall directly on the city itself and are accommodated through taxes and user fees. Wherever the money comes from, the total cost burden ends up falling on tax payers whether local, provincial or federal making this an important public policy consideration.

Q. Are the costs fixed or variable over the time of the scenarios?

A. For the purposes of this type of study the costs are fixed at today's rates. The intent of the study is to compare two fixed points in the future (e.g. business as usual scenario costs and vision scenario costs) therefore, the costs presented provide a relative comparison of the two growth scenarios. The numbers are useful for comparing the implications of the scenarios but should not be relied on in absolute terms or used for the purposes of short term growth management or budgeting.

Q. Do I include the costs of renewal of infrastructure in the study?

A. An important point to consider in this step is the renewal or replacement of the infrastructure. As pipes and facilities age, in addition to ongoing maintenance, they will likely need to be replaced at some point in their lifecycle. Replacement costs are a considerable challenge facing municipalities today as infrastructure ages. With smart growth, a greater amount of new growth is accommodated in existing areas of the city - areas with existing infrastructure. If the infrastructure required for new growth can be coordinated with the timely replacement of existing infrastructure there will likely be financial savings that result. However, the complexity these calculations would be beyond the scope of a study like the one proposed in this Guide.

A key finding that should result from this type of study is that growth and renewal can be integrated, thus saving money. Instead of laying new pipes at the edge of town for the additional population, existing pipes within the city (which are likely near the end of their lifecycle) can be replaced. This results in a win, win situation that accommodates growth and renews infrastructure.

Measure the infrastructure

Q. What are the most common units of measure?

A. Each type of infrastructure will be measured differently depending on how it is constructed and maintained. Transportation infrastructure is usually expressed in kilometers of a certain type of road or rail. A road may be measured on a per lane basis or as an aggregate number. For example a four lane divided roadway may be classified (for the purposes of costing) as four individual travel lanes or as a single four lane road. However the measures are calculated they must be consistent between the two scenarios in order to get valid results for the study.

Some smaller scale linear infrastructure will be expressed on an area basis. For example, the measure for smaller water distribution and collection pipes might be available as a total length per hectare and then calculated on an area basis.

Buildings and facilities are a straightforward measure of single units.

Identify and apply unit costs

Q. How do I identify the unit costs?

Unit cost information for each type of infrastructure is usually held by the operators of the various infrastructure systems. As mentioned previously, it is helpful to have engaged these stakeholders early on so that they understand the implications of providing the information. They can 'make or break' your ability to succeed with this type of study if they feel threatened by the request for data or they misunderstand by the purpose of the study.

Q. How do I incorporate the costs of possible technological changes (that might occur between now and the future time horizon of the scenarios) into the unit costs?

A. This is a challenge to long range planning as there will always be the possibility of technological change during the time line for the scenarios. There are two ways to manage this issue.

The first is to assume that the technological changes over the lifetime of your scenarios will not be greater than the technologies that are feasible today. This is not an unreasonable assumption. For example, transportation infrastructure has seen no radical changes over the last 5 or 6 decades. Changes that have happened have been incremental improvements such as engine efficiencies or the design of vehicles. Therefore the change over the time horizon of the scenario is more likely to be about a greater level of adoption of an existing or feasible technology than the adoption of an entirely new technology – which cannot be predicted anyway. In this case you will use the unit costs of today's technology. If your city is not yet using the technology you can use the unit costs from other cities as benchmarks. Los Cabos's vision scenario included the introduction of bus rapid transit where none existed previously in the city therefore they used unit costs provided by the Mexican Center for Sustainable Transport. In many countries federal transportation agencies will have a set of 'standardized' costs for these types of technologies.

The second way to manage this issue is to develop service level measures instead of measures that might be impacted by technological change. For example, recognizing that the types of technologies it may choose for its rapid transit service was uncertain, Calgary set a performance measure related to frequency of service (less than 10 minutes, 15 hours per day, 7 days a week). A unit cost was then developed for this performance measure based on the current performance of their light rail and bus systems.

The vision scenario may include changes that do not involve a great deal of technological change but do involve some changes of design. For example the hybrid scenario in Calgary incorporated some new road types that did not exist in the business as usual scenario. Once the function of these new road types was described the unit costs were calculated based on existing costs for travel lanes, intersections and other elements of road construction.

Responding to these potential changes is also one of the reasons why master plans must be updated periodically (typically every 5 years) or renewed (typically every 10 years). During the update of master plans, cities and regions can re-evaluate the impact that new technologies or design approaches have had in recent years, and are anticipated to have in the future. Cost of growth analyses should be revised as part of any master plan update.

Report the results

Results of the Calgary Study

CAPITAL COSTS (CANADIAN DOLLARS)				
	DISPERSED SCENARIO	RECOMMENDED DIRECTION	DIFFERENCE	PERCENT DIFFERENCE
ROAD CAPITAL COST	\$17.6	\$11.2	\$6.4	-36%
TRANSIT CAPITAL	\$6.8	\$6.2	\$0.6	-9%
WATER AND WASTEWATER	\$5.5	\$2.5	\$3.0	-54%
FIRE STATIONS	\$0.5	\$0.3	\$0.2	-46%
RECREATION CENTRES	\$1.1	\$0.9	\$0.2	-19%
SCHOOLS	\$3.0	\$2.2	\$0.8	-27%
TOTAL	\$34.5	\$23.3	\$11.2	-33%
TOTAL COSTS (\$BILLION)				

OPERATING COSTS (CANADIAN DOLLARS)				
	DISPERSED SCENARIO	RECOMMENDED DIRECTION	DIFFERENCE	PERCENT DIFFERENCE
ROAD OPERATIONS	\$0.23	\$0.19	\$0.04	-18%
TRANSIT NET OPERATING	\$0.30	\$0.30	\$0.00	-0%
WATER AND WASTEWATER	\$0.06	\$0.03	\$0.03	-55%
FIRE STATIONS	\$0.28	\$0.23	\$0.05	-18%
PARKS	\$0.13	\$0.12	\$0.01	-9%
TOTAL	\$0.99	\$0.86	\$0.13	-14%
TOTAL COSTS (\$BILLION)				

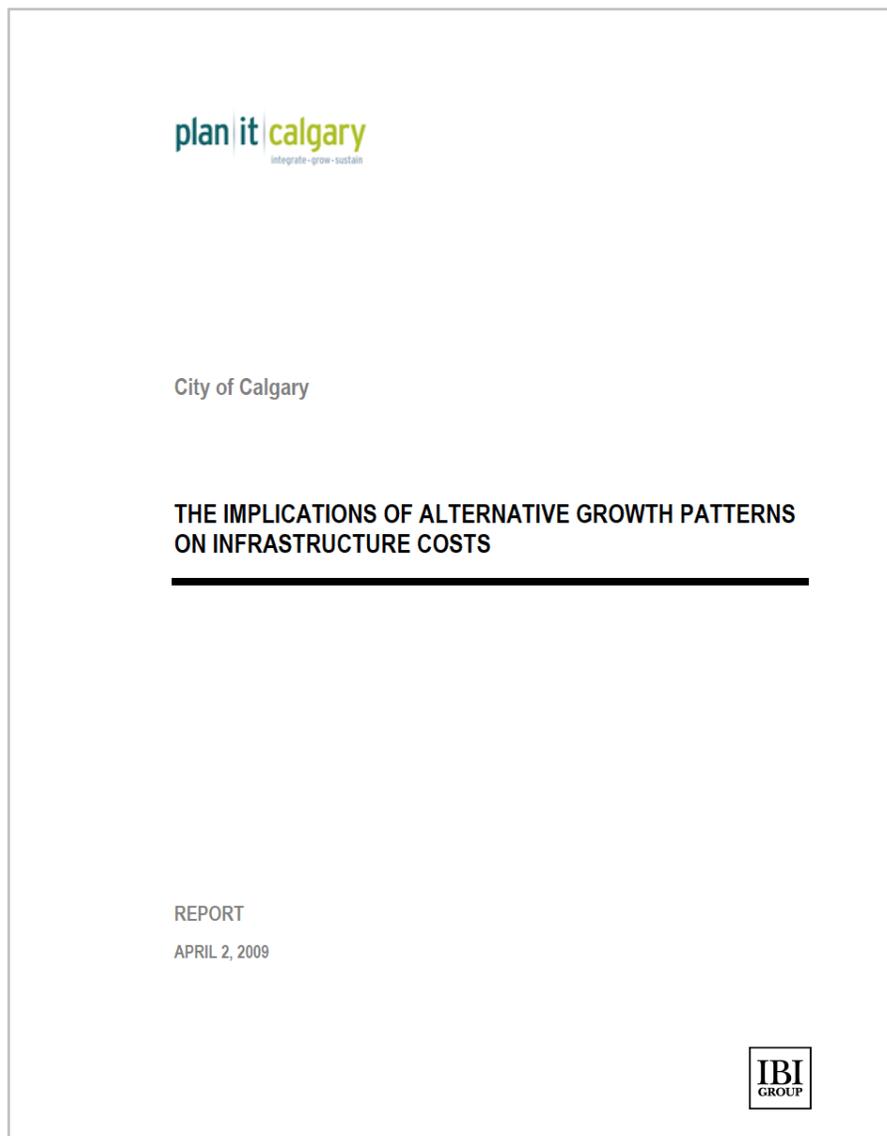
KEY FINDINGS OF THE CALGARY STUDY

- The land required for Plan It Calgary's Recommended Direction is 25% smaller than the Dispersed Scenario (which reflects current policy and trends).
- The cost to build Recommended Direction is 33% less expensive than the Dispersed Scenario.
- The Recommended Direction would be less expensive to operate and maintain over the next 60 years than the Dispersed Scenario.
- The cost to build, maintain and replace aging streets has the largest impact when comparing costs between the two growth patterns. Reduced greenfield growth in the Recommended Direction will result in a 36% cost savings for new streets compared to the Dispersed Scenario, and will also reduce maintenance and replacement costs.
- Enhanced Primary Transit service proposed in the Recommended Direction would actually be less expensive to build than extending transit to suburban communities in the Dispersed Scenario. Increased transit ridership in Recommended Direction, which provides double the service compared to the Dispersed Scenario, means that it would cost approximately the same to operate transit in both growth patterns.
- Reduced greenfield growth in Recommended Direction will result in a 55% cost savings for water and wastewater systems compared to Dispersed Scenario. There would be no net difference in costs for the existing parts of Calgary since replacement of water and wastewater systems will be required as infrastructure ages. Significant intensification of existing areas and growth in new greenfield communities could both trigger the need to upgrade existing systems.

THE IMPLICATIONS OF ALTERNATIVE GROWTH PATTERNS ON INFRASTRUCTURE COSTS

The full Calgary study can be found at:

www.calgary.ca/PDA/LUPP/Documents/Publications/plan-it-calgy-cost-stdy-analysis-april-third.pdf



Results of the Los Cabos Study

CAPITAL COSTS (MEXICAN PESOS)					
		ESCENARIO TENDENCIAL (COSTO DE CONSTRUCCIÓN)	ESCENARIO VISION (COSTO DE CONSTRUCCIÓN)	DIFERENCIA	%
INFRAESTRUCTURA	VIALIDADES	\$194,709,715,200	\$64,213,430,400	\$130,496,284,800	67%
	TRANSPORTE PÚBLICO		\$3,972,500,000	-\$3,972,500,000	
	AGUA	\$9,160,363,096.80	\$2,966,120,942.40	\$6,194,272,154	68%
	DRENAJE	\$15,363,168,474.90	\$4,974,569,898.20	\$10,388,598,576.70	68%
	ENERGIA ELÉCTRICA	\$199,562,919.26	\$91,097,364.30	\$108,465,554.96	54%
	ALUMBRADO PÚBLICO	\$3,543,944,000	\$1,561,680,000	\$1,982,264,000	56%
EQUIPAMIENTO	EDUCACIÓN	\$3,772,331,584	\$2,433,940,664	\$1,338,390,920	35%
	SERVICIOS URBANOS	\$7,025,050,000	\$4,626,350,000	\$2,398,700,000	34%
	SALUD	\$411,366,000.	\$190,587,000	\$220,779,000	54%
	RECREACIÓN	\$72,299,500,000	\$103,849,200,000	\$31,549,700,000	-44%
TOTAL		\$306,485,031,274.96	\$188,879,476,268.90	\$117,605,555,006.06	38%
TOTAL COSTS (\$BILLION)					

OPERATING COSTS (MEXICAN PESOS)

		ESCENARIO TENDENCIAL (COSTO DE CONSTRUCCIÓN)	ESCENARIO VISION (COSTO DE CONSTRUCCIÓN)	DIFERENCIA	%
INFRAESTRUCTURA	VIALIDADES	\$3,138,103.50	\$1,016,113	\$2,121,9903.50	68%
	TRANSPORTE PÚBLICO				
	AGUA	\$2,290,098,274.20	\$741,530,235.60	\$1,548,568,038.60	68%
	DRENAJE	\$3,840,769,703.70	\$1,243,635,216.60	\$2,597,134,487.10	68%
	ENERGIA ELÉCTRICA				
	ALUMBRADO PÚBLICO	\$460,925,005.82	\$172,707,752.88	\$288,217,252.94	63%
EQUIPAMIENTO	EDUCACIÓN				
	SERVICIOS URBANOS				
	SALUD				
	RECREACIÓN	\$1,195,523,000	\$968,538,200	\$226,984,800	19%
	RECREACIÓN	\$7,790,454,087.22	\$3,127,427,518.08	\$4,663,026,569.14	60%
TOTAL COSTS (\$BILLION)					

KEY FINDINGS OF THE LOS CABOS STUDY

- Both scenarios are based on the same growth projection of 600,000 inhabitants by 2040. However the Vision scenario uses 45% less area than the Business as Usual (BAU) scenario resulting in savings of 13,219 hectares of land. In that sense, the vision scenario increases to almost twice the density per hectare.
- The difference between construction costs for both scenarios is 38%. The construction of infrastructure and equipment costs in the Vision scenario is 117 billion pesos less than Business as Usual by 2040.
- For operating and maintenance costs, it was found that the Vision scenario reduces the spending every year until it reaches a cumulative total of 60% less than the BAU scenario by 2040. Savings of 4 thousand 500 million pesos are achieved.
- In the Vision scenario there is a 67% savings in the cost of building new roads in relation to what it would cost in the BAU scenario. The difference between the two scenarios is 130 billion pesos.
- The Vision Scenario considers incorporating a BRT (Bus rapid transit) line as part of the public transit system. Because of this the Vision Scenario identifies approximately 4 thousand million pesos more than the BAU scenario. However, compared with the investment that would need to be done in building new roads in the BAU scenario, this investment represents only an increase of 3%.
- The Vision scenario proposes to create about 15 m² of green area per inhabitant, which exceeds the recommendation of the World Health Organization, which suggests having between 9 and 12 m² of green area per inhabitant. This strategy increases significantly the recreational area spaces (parks) and means an increase in the construction cost of 43%, meaning it would need an investment of 31,550 billion pesos more than the BAU scenario.

The full Los Cabos study can be found on the Municipal Planning Institute of Los Cabos website: <http://implanloscabos.mx/estudios/>



Fotografía Jana Husaríkova

Estudio de Implicaciones de los Modelos
de Crecimiento en el Costo de Infraestructura:
Caso de Estudio Los Cabos

