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Planning a path towards sustainable energy development

A case study of electricity system planning in Ontario, Canada

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Author’s declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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ABSTRACT OF THESIS submitted by:
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Fostering perpetual improvement towards greater efficiency and environmental performance is possibly the greatest challenge facing the development of sustainable energy systems. The long term development of efficient, reliable, and environmentally sustainable electricity systems is a challenge facing the Canadian province of Ontario. The Integrated Power System Plan for Ontario aims to direct the development of a sustainable electricity system for the Province through recommendations for the establishment of supply and demand infrastructure. The Plan recommends an ambitious expansion of conservation and renewable generation efforts. The approach to conservation is progressive and oriented to foster perpetual improvement by designing programs to foster the acquisition of new information. The IPSP suffers from an inadequate approach to the pursuit of renewable generation that is not sufficiently oriented towards the acquisition of information in pursuit of solutions. The IPSP appears likely to establish an efficient and reliable electricity system. Its ability to progressively improve the electricity system's environmental performance is more uncertain. Negative externalities are insufficiently incorporated into the decision making framework and further integrations would facilitate the comparison of alternative resources supply options on equal footing. Future plans must integrate negative externalities and more actively pursue information needed to overcome the limitations associated with expanding renewable and low carbon electricity generation options.

Keywords: sustainable energy development, electricity system planning

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List of Abbreviations

CCGT	Combined Cycle Gas Turbine
CHP	Combined Heat and Power
ECSTF	Electricity Conservation and Supply Taskforce
EM&V	Evaluation, Monitoring and Verification
IEA	International Energy Agency
IESO	Independent Electricity System Operator
IGCC	Integrated Gasification Combined Cycle
IPSP	Integrated Power System Plan
IRP	Integrated Resource Planning
kWh	Kilowatt Hour
LCA	Life Cycle Assessment
LUEC	Levelised Unit Electricity Cost
MW	Megawatt
OEB	Ontario Energy Board
OECD	Organisation for Economic Cooperation and Development
OPA	Ontario Power Authority
OPG	Ontario Power Generation Inc.
SCGT	Single Cycle Gas Turbine
TRC	Total Resource Cost
TWh	Terawatt Hour
UN	United Nations
WSSD	World Summit on Sustainable Development

1. Introduction

Modern energy systems provide numerous essential services for human societies and are integral to development. The transportation of goods, personal mobility, heating and electricity services for household, commercial, agricultural and industrial purposes are all made possible by the systems that convert primary sources of energy such as fossil fuels into useable forms. Despite the importance of energy for modern societies, there are many structural problems: adverse environmental effects include climate change and air pollution associated with the combustion of fossil fuels, as well as habitat loss and fragmentation associated with the development of large-scale hydroelectric projects and electricity transmission networks. Dependency on foreign supplies of oil and other primary energy sources are also an inherent element of many industrial economies. Providing clean, reliable and affordable energy services remains an ongoing challenge. Such problems have lead to increasing recognition of the urgent need to transform modern energy systems, setting them on the path to a more sustainable future (G8 2005; IEA 2007a).

The enormity of the challenge posed by a societal transition towards sustainability is at once daunting and opportune (Raskin et al. 2002). Perhaps nowhere is this challenge more acute than in the context of energy and climate change (G8 2005). Global demand for primary energy is projected to increase by 55% by 2030 if existing policies remain in place. The increasing use of fossil fuels (coal, oil, gas) to meet this demand is projected to result in a corresponding 57% increase in CO_2 emissions. By comparison, estimates suggest the stabilization of atmospheric CO_2 concentrations thought to prevent dangerous anthropogenic interference with the global climate will require the stabilization of emissions well below present levels (Pacala and Socolow 2004). It is clear the stabilisation and reduction of greenhouse gas emission levels demands unprecedented policy action and transformations of modern energy systems (IEA 2007; IPCC 2007b).

The necessity of steering energy systems in more sustainable directions is clear – the means through which this might be achieved however is not. There is evidence to suggest the unprecedented and heroic challenge of stabilising and reducing greenhouse gas (GHG) emission levels could be resolved through its dissection into a limited number of merely monumental tasks associated with the wider adoption of established and emerging technologies (Pacala and Socolow 2004). Yet, the uptake of many such technologies appears not to be occurring at a scale and pace commensurate with the task; the reasons for which are perhaps more political and institutional, than they are technological (Caspary et al. 2007). Despite the potential negative long term economic consequences of inaction, many governments are hesitant to take action that potentially risks undermining or even moderating short term social and economic gains (Stern 2007).

Sustainability meanwhile, remains a normative, if contested, goal of numerous governments and organisations (Meadowcroft 2007). Finding balance amidst disagreements over problem structuration (among others) poses enormous challenges for the existing institutional structures tasked with implementing sustainable development, especially in the context of energy and climate change. Accordingly, attention has increasingly focused on processes of governance, where fostering change in the direction of sustainable development is pursued through open processes, oriented towards long term outcomes in pursuit of acquiring the information necessary to effectively integrate social, economic and environmental considerations into decision making (OECD 2002; Kemp et al. 2005; Smith et al. 2005, Hendriks and Grin 2007; Meadowcroft 2007). Such approaches recognize that responding to the sustainability challenge facing modern energy systems requires changes in many facets of society beyond merely the technological. Changes are necessary in the institutional (e.g. regulation), economic (e.g. patterns of investment), and cultural (e.g. user preferences) configurations that comprise modern energy systems. Still, the persistent complexity and uncertainty that pervades alternative courses of action suggests that addressing such a “wicked” problem – where decision stakes and uncertainty are both high – cannot simply be planned for in a linear manner (Rittel and Webber 1973).

A further challenge exists in arriving at operational definitions of sustainable energy systems. Vast improvements in energy efficiency, the expanded production of energy from renewable sources, as well as the development and implementation of promising yet uncommercial technologies (e.g. CO_2 capture and sequestration) are all elements of a more sustainable energy future. Recent efforts by leading international agencies[1] have lead to the development of energy indicators for sustainable development which aim to facilitate monitoring and shift the focus further towards progress rather than focus exclusively on achieving a particular goal (Vera and Langlois 2007). Important parallels with conceptualizations of sustainable development in general are noticeable where the concept of sustainability offers a normative orientation for policy rather than a concrete decision-making rule (Lafferty 1996). In this vein the elements of sustainable energy systems should be open to continuous debate and reassessment as knowledge and understanding of the direction of change improves. Still, acquiring and integrating such information remains an intractable problem. Initiating a process of transition towards secure, sustainable energy systems remains elusive for both developed and developing economies (IEA 2007b). Much research has examined the issues surrounding sustainable development and climate change mitigation in the context of developing countries; however, research in the context of developed countries is lacking (Sathaye et al. 2007). Recent evidence also suggests energy developments within industrialising countries are unlikely to leapfrog or escape carbon lock-in to fossil fuel dependent energy systems (Unruh and Carrillo-Hermosilla 2006). As such, understanding the effectiveness of approaches for implementing a transition towards less-carbon intensive energy systems within industrialised countries is of critical importance.

The focus of this thesis is on how industrialised countries pursue the development of sustainable energy systems by employing a case study in the field of electricity system planning from the province of Ontario, Canada. With a population greater that 12 million people, and a land mass larger than 900 000 km^2, the province of Ontario is larger than many countries (Ontario MoF 2006). Under Canada's federal system of government, the provinces retain jurisdictional responsibility for their electricity regimes. Ontario's electricity market was deregulated in 1998, and it has been approximately 20 years since comprehensive planning for the province's electricity needs was undertaken (ARP 2007). Ontario electricity system development occurs within the overarching Energy Sector Transformation Program and an Integrated Power System Plan (IPSP) has recently been completed for the Province of Ontario, covering a period of 20 years with a strategy to provide a "clean, reliable, diverse and sustainable electricity supply for the province" (Duncan 2005).

Examining electricity system planning can illuminate how public institutions approach the challenges associated with the development of sustainable energy systems. If a transition towards sustainable energy futures is agreed strategy, what mechanisms are necessary for its realisation; and, how well-suited are planning approaches to addressing the challenges?

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[1] International Atomic Energy Agency, International Energy Agency, United Nations Department of Social and Economic Affairs, Eurostat, and the European Environment Agency

1.1 Purpose of Study

The purpose of this study is to examine the extent to which planning can foster the long term development of a sustainable electricity system and assess the ability of strategies to capitalize on opportunities and answer challenges.

1.2 Research Objectives

The following research objectives will guide the study:

1. Describe the challenges associated with sustainable energy development for modern energy systems;
2. Examine approaches to sustainable energy development through an empirical analysis of electricity system policy and planning in Ontario, Canada in light of contemporary thinking on energy for sustainable development and;
3. Draw recommendations and implications for efforts aimed at steering energy systems in the direction of sustainability especially in the case of Ontario.

1.3 Methods

At the outset of this study, pertinent literature on the development of sustainable energy systems was reviewed for the purpose of identifying key elements of sustainable energy systems. Building on the literature, the primary method of data collection entailed an in-depth document analysis of planning documents pertaining to the Integrated Power System Plan (IPSP) for Ontario for the period 2007-2027. On August 29, 2007 the Ontario Power Authority (the public agency responsible for production of the IPSP) submitted the IPSP to the Ontario Energy Board (the Provincial Energy Regulator) for approval. The evidence submitted for consideration contained evidence on *Stakeholder Engagement, Conservation and Supply Resources, Transmission*, the *Procurement Process,* and *Plan Outcomes*. The documentation submitted consists of over 150 separate documents covering nearly 7000 pages of evidence.[2] In addition, relevant grey literature and government documentation pertaining to Ontario's electricity system and relevant initiatives were also examined for the purpose of framing Ontario's electricity system and the IPSP within it. In the course of conducting the analysis, several research questions guided the examination of the IPSP

1. What are the primary elements of the Provincial government strategy guiding electricity system development?
2. How does planning elaborate and operationalise the consequences of policy in a formal manner?
    a. Which principles guide the IPSP?
    b. How does the IPSP address uncertainty, and to what extent is the IPSP oriented to facilitate learning?
    c. How does the approach to electricity system development address and attempt to overcome the challenges associated with steering energy systems towards sustainability?

Data collected through document analysis was supplemented with key informant interviews with individuals from the Ontario Ministry of Energy and the Ontario Power Authority (OPA) for the purpose of generating a more in-depth picture of the planning

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[2] Appendix I: Key IPSP Documents

process and to gather insight into the realities facing individuals and institutions tasked with managing the development of modern energy systems.[3]

1.4 Scope and Limitations

This analysis is an examination of the strategic actions taken towards the development of a sustainable electricity system through an empirical analysis of the Integrated Power System Plan, 2007-2027 for the Province of Ontario, Canada. In preparation of the IPSP numerous supplemental and supportive assessments were conducted by several public and private agencies. Such analyses contain valuable information and were reviewed where appropriate; however, a thorough assessment of their quality, accuracy, and assumptions was beyond the scope of this study. Rather, this analysis seeks to examine the strategic actions taken within the IPSP based on the information available and the rationale underlying those decisions.

There are two primary components of the IPSP process: (1) planning the development of the necessary supply and demand infrastructure; and (2) establishing a procurement process for engaging the private sector in the development of infrastructure needs as defined by the planning process. Although the process for procuring private sector investment in infrastructure is an important influence on IPSP implementation and the costs thereof in particular, this analysis will forgo an assessment of the procurement process in favour of focusing on the strategic decisions surrounding the development of particular supply infrastructure. Ultimately, it will be the recommended supply infrastructure – determined via the IPSP – that will shape the resources which must be procured. The procurement process will however, be referred to where appropriate.

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[3] Appendix II: Individuals Interviewed

Prior to the initiating the IPSP process, the government of Ontario initiated a series of procurement initiatives for energy conservation and renewable generation projects. Throughout the IPSP these resources are referred to as "committed resources" which are in addition to "existing resources". It is beyond the scope of this analysis to review the circumstances, processes and analyses that were developed in support of the "committed resources". Rather the scope of this analysis is limited to "planned resources" as outlined in the IPSP, and the context surrounding their establishment.

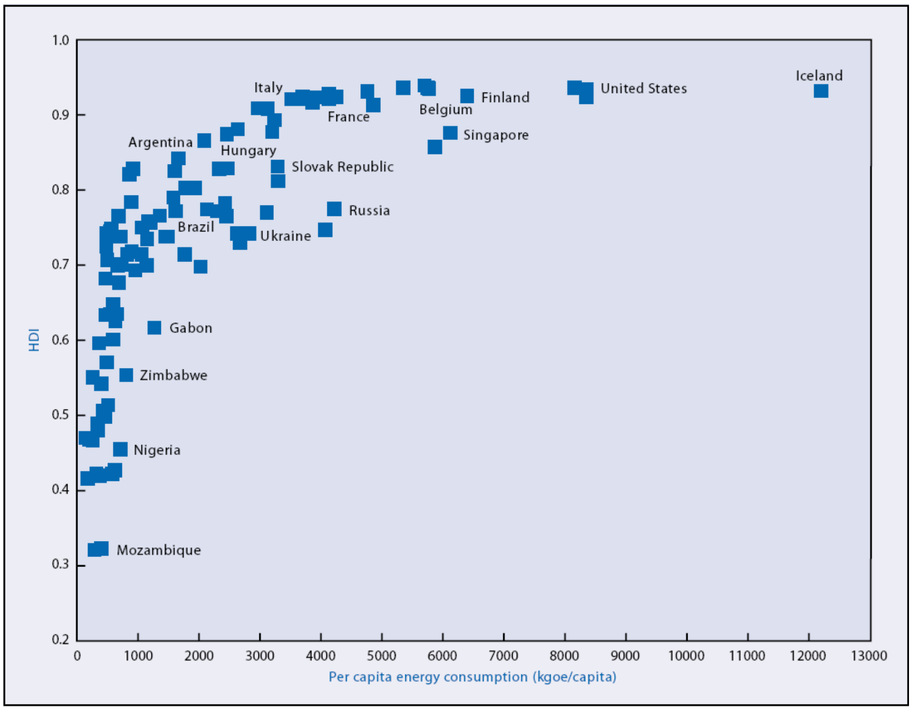
One further limitation arises from the examination of a single case for the analysis. Unfortunately, examining other jurisdictions in depth was beyond the scope of this study. In practice, this limits the ability to generalise and apply the results to other jurisdictions on a wider scale. Still, in light of the many challenges facing sustainable energy development, illuminating the challenges facing one jurisdiction remains worthwhile to the extent that future comparisons with other jurisdictions remain a possibility.

2. Energy Systems and Sustainability

The provision of, and access to energy services clearly plays an important role in development. The United Nations' Human Development Index, a composite measure of socio-economic well-being, shows a clear relationship between human development and per capita energy consumption in many countries (Figure 2.1). Access to energy services is of vital importance for realising sustainable development, that is, development which meets the needs of present generations without compromising the needs of future generations to meet their own (Spalding-Fecher et al. 2005). As such, supporting sustainable development implies the development of sustainable energy systems with appropriate respect for the social, economic and environmental dimensions of energy supply and use. Realising sustainable energy development however, insofar as conventional means of delivering energy services are concerned, remains an intractable problem for modern energy systems. Based on current trends, modern energy systems cannot be considered sustainable (Jefferson 2006; IEA 2007a).

This section presents an overview of modern energy systems, trends in their development as well as the broader trends shaping that development. It will also outline the elements of sustainable electricity systems as well as the forces driving changes to, and the associated responses of regulatory regimes governing electricity systems.

Figure 2.1 Relationship between Human Development Index and per capita energy use, 1999/2000

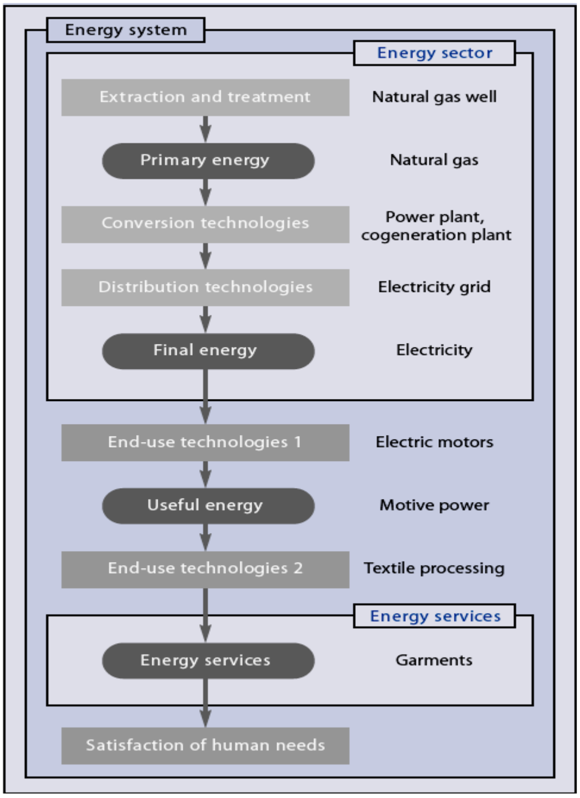


Source: Goldemberg and Johansson 2004

2.1 *Energy Systems in Context*

Technology is an inherent element of modern energy systems. Technological capacity underpins the energy supply sector from extraction to end-use. Extraction, conversion, distribution and end-use technologies comprise modern energy chains which transform primary sources of energy into the services that human societies demand (Figure 2.2). Although the supply of energy remains important, the nature of modern energy systems hinge on the services they provide: illumination, cooking, telecommunications, heating, cooling, transportation and many other services within domestic, commercial, agricultural and industrial spheres. As such the delivery of energy services to industrial societies requires complex combinations of infrastructure, technology, and knowledge (Goldemberg and Johansson 2004).

Figure 2.2 Example energy system



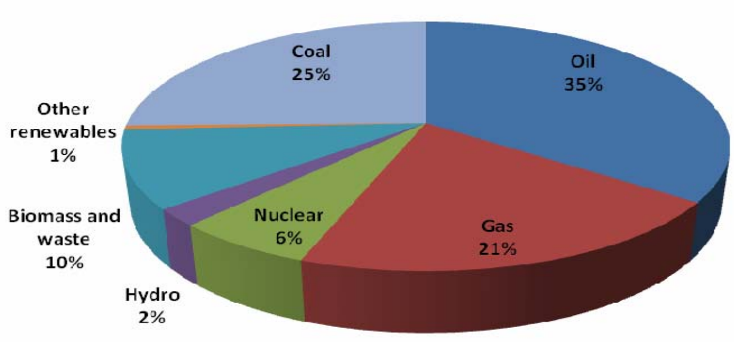
Source: Goldemberg and Johansson 2004

Although the modern energy chain seen in Figure 2.2 is conceptually useful, its technological emphasis presents an underdeveloped picture of the socio-political, economic and environmental dimensions of modern energy systems. In addition to the technological (e.g. electricity generation), energy systems are also a mix of institutional (e.g. regulation), economic (e.g. capital), and cultural (e.g. user preferences) elements that influence economic, social and environmental outcomes. These dimensions add an additional layer of complexity to efforts aimed at steering them in the direction of sustainable development.

2.1.1 Global trends in energy

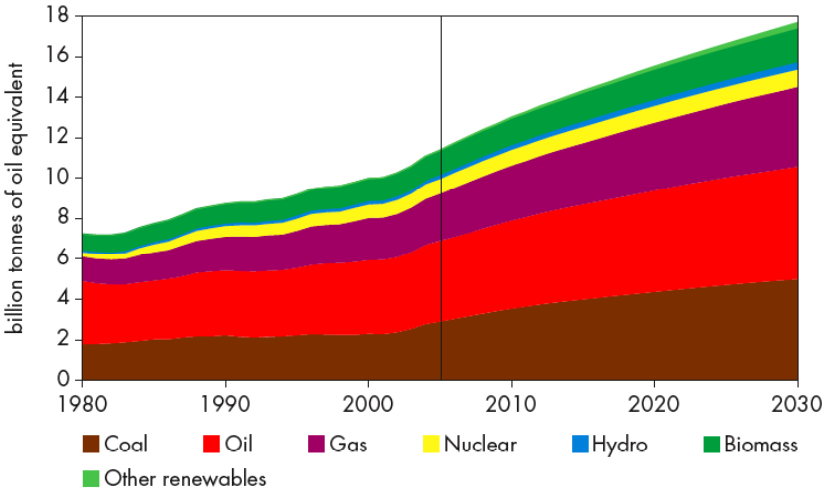
An overwhelming amount of the world’s primary energy demand – over 80% – is provided by fossil fuels (Figure 2.3). In the absence of concerted policy action (i.e. business as usual based on current policy), the global demand for energy is projected to grow substantially (55%), with 84% of this growth met by increased fossil fuel usage (Figure 2.4). Much of this growth (approximately 74%) will occur in developing countries especially India and China who together are projected to account for 45% of this growth. Based on current trends two interrelated aspects of this projected growth are particularly noteworthy. First, energy demand growth is expected to be greatest for coal, growing 73% between 2005 and 2030. Second, electricity use is projected to nearly double, significantly increasing its share of final end-use consumption from 17% to 22%, much of which will be generated through coal-fired electricity generating stations established in developing economies (IEA 2007b).

Figure 2.3 World primary energy demand, 2005



Source: IEA 2007b

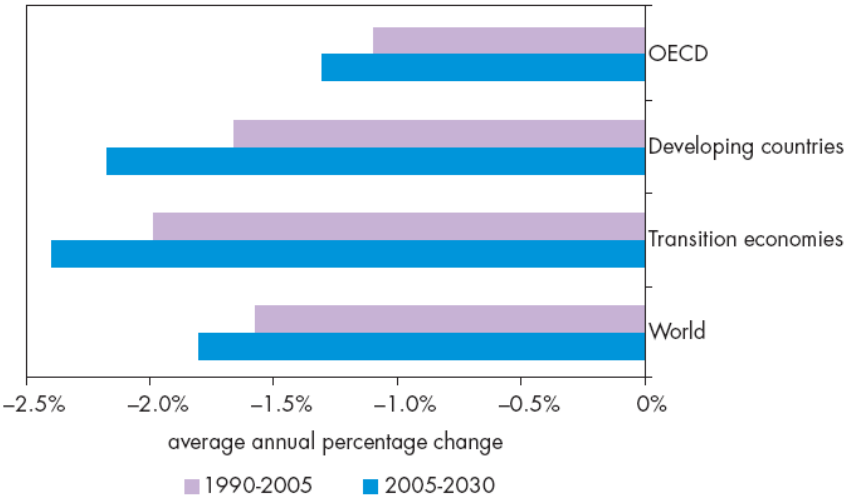
Figure 2.4 Projected world primary energy demand, reference scenario



Source: IEA 2007b

A substantial amount of the growth in energy demand is associated with the economic growth. So much so that improvements in energy intensity (i.e. efficiency) expressed as total energy use per unit of gross domestic product are unable to keep pace with the growth in demand. The above figures for instance, are inclusive of decreases in energy intensity which, between 1990 and 2005, on a global scale fell 1.6% per year and are projected to decrease by 1.8% between 2005 and 2030 (Figure 2.5). Moreover, even within highly industrialised member countries of the IEA[4], energy efficiency improvements were offset by a 14% increase in energy consumption between 1990 and 2004 (IEA 2007a). Curbing this considerable growth in primary energy demand presents a considerable challenge for steering energy in the direction of sustainability. Growing populations and economies typically result in growing energy demand. This challenge is particularly acute in the context of efforts to deliver modern energy services to the approximately 2 billion individuals without access (Goldemberg and Johansson 2004). Decoupling energy consumption from economic development remains a critical task.

Figure 2.5 Primary energy intensity, reference scenario



Source: IEA 2007b

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[4] 14 member countries for which data were available account for 85% of final energy use by all IEA countries and include Austria, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, New Zealand, Norway, Sweden, the United Kingdom, and the United States

The climate change implications associated with the above projections are considerable. The aforementioned growth in energy demand is projected to result in 57% increase in CO_2 emissions between 2005 and 2030 (IEA 2007b). Even within 14 highly industrialised countries of the IEA recent trends suggest modern energy symptoms are not on a path to sustainable futures with CO_2 emissions increasing by 14% between 1990 and 2004 (IEA 2007a). Furthermore, in 1970 renewable energy provided 24% of electricity generation needs for IEA countries however this figure had declined to 15% in 2001 (Jefferson 2006).

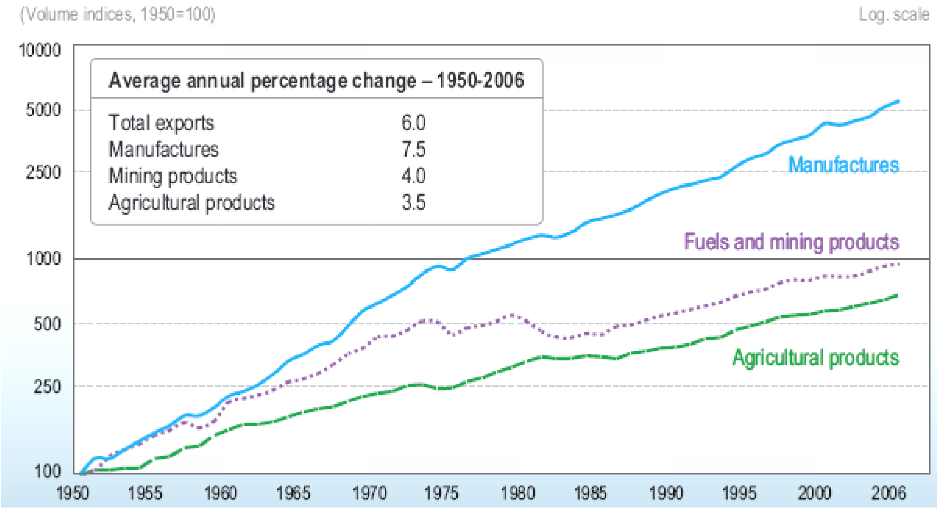
2.1.2 Trends shaping energy development

Increasing consumption, imports, and emissions are occurring in the context of broader trends shaping the global energy landscape. Globalisation, the emergence of the information technology revolution, and the restructuring and liberalisation of energy markets have altered the responsibilities of governments who are increasingly seeking and incorporating broader participation into decision making in the energy field (Johansson and Goldemberg 2002).

Efforts to remove international trade barriers have vastly expanded the volume of goods traded internationally (Figure 2.6) resulting in a deeply integrated global economy. On one hand the emergence of the information technology revolution has contributed to the expansion and integration of the global economy, on the other it holds a vast potential for rapidly helping decouple energy use from energy consumption and reducing CO_2 emissions (Ugo 2007).

Trends towards the restructuring and liberalisation of energy markets have increasingly sought to attract private investment and generate enhanced competition and greater efficiencies as demonstrated by, for instance, the European Union’s push to create a single electricity market (Jamasb and Pollitt 2005). Decisions regarding the allocation of resources, investment, and the implementation of technologies are, to a much greater extent than ever before, in the hands of private actors, subject to market conditions. All of which has altered the roles of government with respect to the provision of energy services.

Figure 2.6 World trade volumes, 1950-2006



Source: WTO 2007

As regulatory frameworks change it has become increasingly important for governments to ensure public benefits are maintained in the context of what are in most cases partially market-driven energy sectors (Johansson and Goldemberg 2002). Likewise, civil society has increasingly sought to influence public policy decisions pertaining to energy and climate change at local, national and international levels. For instance, the "United Nations Climate Change Conference in Bali" held 3-15 December 2007, hosted over 10,800 participants, 5800 of which were representatives of intergovernmental agencies, non-governmental organisations, as well as UN bodies and agencies (IISD 2007).[5]

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[5] Thirteenth Conference of the Parties (COP 13) to UN Framework Convention on Climate Change (UNFCCC) and third Conference of the Parties/ Meeting of Parties to the Kyoto Protocol (COP/MOP 3)

Such trends are important influences on the development of modern systems for the generation, transmission, distribution and consumption of electricity. The increasing recognition of the threat posed by climate change, and the longer term emergence of the sustainable development paradigm has confounded regulatory regimes tasked with addressing an increasingly complex public policy issue.

2.1.3 Electricity sector reform in industrialised nations

Conventional electricity systems have historically shared almost universally common institutional and technical features. Large scale hydro and steam turbine technologies for electricity generation played a key role in shaping modern electricity systems. Electricity policy was designed to realise economies of scale associated with large technological infrastructure, typically generated at large, remotely situated yet centralised stations, delivered via networks of high voltage transmission lines, which often fed into local distribution networks or even directly to highly consumptive industries.

Typical ownership of electricity systems has consisted of an integrated monopoly structure, often but not always owned and operated by government (with oversight by a regulator), and generally considered a public good with tariff structures set according to policy rather than economic considerations (Patterson et al. 2002). These structures were put in place due to the natural monopoly characteristics of electricity systems where, due in part to the considerably large economies of scale, a single monopoly provider could deliver electricity services (through integrated generation, transmission and distribution) more efficiently than the competing firms with, for instance multiple transmission grids.

Another rationale for the persistent structures of electricity systems relates to the public good character of, and the fundamental importance of electricity systems. Although electricity is not strictly speaking a public good (e.g. it is possible to exclude users), its public good attributes derive from the fact that public benefits are broader than simply light, heat or motive power. As Jaccard and Mao (2002) explain:

> Electricity enables advanced communications, education, and training opportunities; more effective domestic lighting; dramatic time saving in domestic chores; more productive and reliable production processes; and many other social development benefits that markets tend to undervalue. Therefore, governments of industrialised countries, especially in the past, and developing countries, today, play an active role in pursuing widespread electricity access and use through state enterprises and public subsidies for energy production and for extension of distribution systems.

In short, the widespread use and availability of electricity was and is deemed essential to the development of an industrialised economy. Electricity policy was often linked with or viewed as a subset of industrial development policy where a secure supply coupled with price stability is a key ingredient for a functioning economy (Schott 2005). Moreover, integrated electricity systems are far more complex than those necessary to deliver most private goods such that the view of electricity as an essential service, if not a public good, persists (Doern and Gattinger 2003). Governments have therefore sought to intervene through variety of mechanisms including controlled-prices, subsidies, regulation and state control.

The structures described have been very successful in delivering nearly universal access to electricity services within industrialised nations. Over time however, ideological preferences, technological developments and inefficient outcomes associated with such structures drove policy makers to increasingly reconsider the structure of electricity systems. In addition, the emergence of the sustainable development paradigm, the issue of climate change on the international agenda, concerns over air pollution, and the risks associated with nuclear accidents have further influenced efforts to restructure electricity systems. As have arguments for the internalisation of external costs as well as industry efforts pushing for flexible market-type instruments and incentive based regulation for both economic and environmental aspects (Doern 2007).

Over time the ability to realise increasing returns through ever greater economies of scale with conventional technologies has weakened. Innovative technologies such as gas turbine generation – which are highly efficient and favour smaller scales and locations close to users – can be operational within 2 years. Large hydro, coal or nuclear generating stations by contrast may require 6 years or more, an inherently riskier investment (Patterson et al. 2002). The emergence of such smaller scale, competitive generation technologies has served to undermine the public good arguments as well as challenge the view that regulated monopolies are the most efficient structures (Jaccard and Mao 2002; Plourde 2005).

Interest in electricity sector reform has also stemmed from the perception that central planning and monopoly structures failed to deliver the necessary accountability for investment decisions to taxpayers who were also captive customers. Increasingly scarce public funds in many countries drove governments to reconsider public financing of the large infrastructure projects of the past. Likewise, the economic efficiency of state-run enterprises was also increasingly questioned. In market economies, market forces require competing producers to continuously strive for productivity gains particularly where consumers have the choice to switch to lower cost suppliers. Such forces drive technological development further enhancing the efficiency with which services are delivered – forces largely absent or much weaker in planned economies or monopoly sectors (Jaccard and Mao 2002).

During the 1980s and 1990s governments in many western countries who favoured free market solutions began to disassemble the monopoly structures in place for many electricity systems, selling state owned assets, encouraging competition and aiming to attract investment for the delivery of electricity services. Achieving greater operating efficiencies through the introduction of competitive generation was the aim, as was exposing investment decisions to greater scrutiny, creating incentives for private investment in generation, and further engaging the private sector in stimulating innovation (Dewees 2005). Over time, a basic consensus on restructuring electricity sectors has coalesced around four generic elements (Table 2.1).

Table 2.1 Elements of electricity sector reform

Restructuring	Vertical unbundling of generation, transmission, distribution and retail activities Horizontal splitting of generation and retail supply
Competition and Markets	Wholesale market and retail competition Allowing new entry into generation and retail supply Electricity trading
Ownership	Allowing new private actors Privatising existing publicly owned business
Regulation	Establishing independent regulator Provision of third party network access Incentive regulation of transmission and distribution networks

Source: Jamasb and Politt 2005

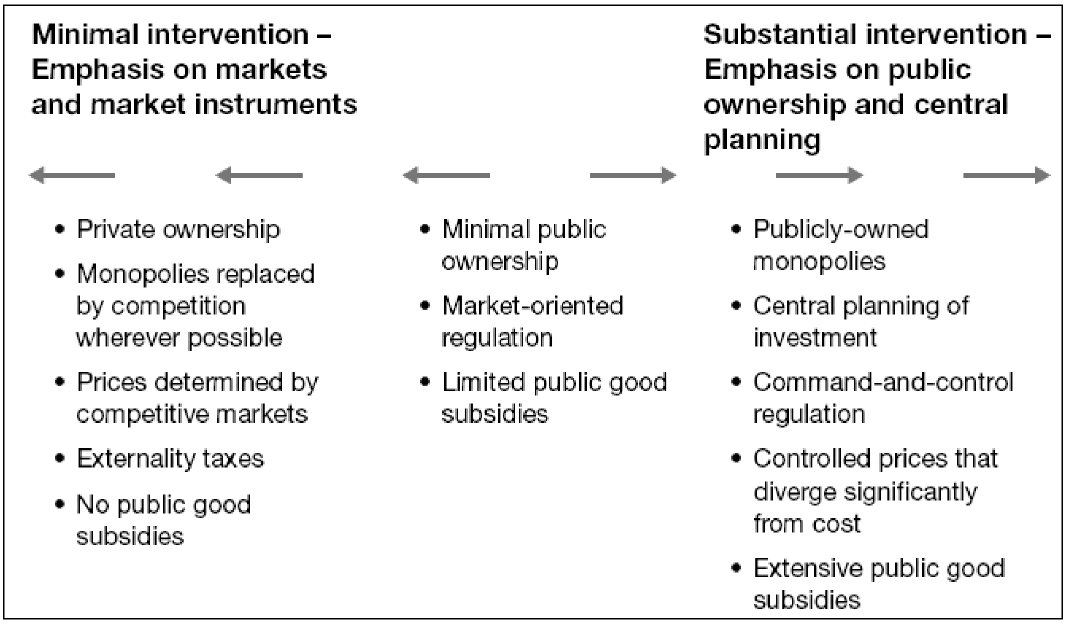
Efforts to reform electricity sectors have appeared under various headings sometimes referred to alternatively as deregulation, liberalisation, or restructuring. The terms however are neither synonymous nor necessarily mutually inclusive. This analysis employs the term restructuring to refer to efforts to disaggregate the electricity sector and encourage competition and investment in at least some facet of the electricity regime. Deregulation however, suggests the removal of regulation governing the electricity regime which is not necessarily the case. Efforts to restructure for instance are nearly always accompanied by the establishment of independent regulators who may very well increase, encourage or necessitate the establishment of further rules or regulation (Doern 2007). Restructuring may result in new regulation, but is unlikely to represent the end of regulation.

Facilitating competitive generation markets forms the core of restructuring efforts (Dewees 2005). In principle, competitive generation will determine the wholesale electricity price according to supply and demand interactions with the introduction of competition establishing incentives for investment in new generating capacity as necessary (where sufficient returns on investment are created). In combination, regulated transmission and distribution networks (to balance their natural monopoly characteristics) have persisted as basic elements.

Although a degree of consensus exists around the elements of electricity sector reform, it is worth emphasising that both concepts and implementation have differed widely in different jurisdictions. The appropriate configuration for restructured energy sectors to best encourage competition as well as attract investment and entrepreneurship remains subject to much uncertainty, and may depend on context specific circumstances or ideological preferences rather than an objective assessment of effectiveness (Patterson et al. 2002; Jamasb and Pollitt 2005). The monopoly provider may sell or lease ownership of generation resources, or alternatively, large existing regulated utilities may retain their dominant position. Likewise, retail competition may be introduced where electricity retailers compete for service delivery to domestic and commercial consumers. In which case a question arises of whether retail competition concerns the delivery of solely electricity units (e.g. kWh) or electricity services. Conversely, retail prices may also be set by regulators and market instruments may be employed to internalise some of the external costs associate electricity production.

It is useful to conceive of government intervention as occurring along a continuum (Figure 2.7). Figure 2.7 provides an analytical framework for characterising the extent and form of government intervention in energy systems. Understanding where along the spectrum (i.e. the extent of intervention) a government's energy policy is provides a useful framework for analysing the approaches employed in shifting the system along a more sustainable trajectory.

Figure 2.7 Intervention spectrum in energy systems



Minimal intervention – Emphasis on markets and market instruments

Substantial intervention – Emphasis on public ownership and central planning

- Private ownership
- Monopolies replaced by competition wherever possible
- Prices determined by competitive markets
- Externality taxes
- No public good subsidies

- Minimal public ownership
- Market-oriented regulation
- Limited public good subsidies

- Publicly-owned monopolies
- Central planning of investment
- Command-and-control regulation
- Controlled prices that diverge significantly from cost
- Extensive public good subsidies

Source: Jaccard and Mao 2002

The challenge of delivering reliable, affordable and sustainable electricity services must account for several unique characteristics electricity systems: (i) large sunk investments constrain opportunities for new entrants, (ii) vertically oriented production segments (generation, transmission, distribution, retailing) are each subject to their own unique, optimal scale, and (iii) electricity is a commodity with unique physical properties (storage is expensive) that requires a simultaneous balance between production and consumption throughout all points in the system (Jamasb and Pollitt 2005). Real-time balancing of the system requires accurate forecasting of both average and peak demand, which must then be matched with generation and transmission capacity necessitating the use of sophisticated and expensive information technology. The system must also be capable of responding to unexpected changes in any one of these system elements. All of which points to the necessity of a central system operator serving a critical coordinative function (Plourde 2005).

Coordination is further essential to the extent that a combination of resources is required to meet (i) baseload, (ii) intermediate, and (iii) peak demands. Resources suited to meeting baseload capacity operate at constant generation rates and are in operation continuously for much of the time. Characterised by comparatively low marginal costs, baseload resources exhibit lengthy times for starting up and shutting down. They are also often restricted in their capacity to adjust output according to short term demand fluctuations. Nuclear power for instance is considered a baseload resource. Hydro power resources, while suited to baseload generation as well, are also more capable of responding to demand variations.

Intermediate resources exhibit greater capacity to adjust to daily demand variations but are subject to higher marginal costs. Natural gas and coal fired generation stations are effective intermediate resources. Peak resources are capable of generating quick responses to short term pulses in demand that can occur at any time or in response to the unexpected loss of a particular resource elsewhere in the system. Such peaking resources include hydro with storage as well as single cycle gas turbines.

In many cases different sources of electricity are better suited to meeting different aspects of the load profile than others. Intermittent resources, such as wind power and run of the river hydro do not necessarily fit neatly into the above categories because they generate electricity when conditions permit. Although large scale hydro-electric facilities are capable of meeting all aspects of the load profile, available hydro power capacity is seldom sufficient to meet total demand. In which case a mix of resources is required to provide: base load requirements at low marginal cost; intermediate increases that occur for instance, during week-day mornings; and, peak resources for temporarily sharp increases in demand (OPA 2005).

Within market-oriented schemes regulators must ensure that private firms are capable of raising capital for future investments in desired resources, which means they must be capable of generating a suitable return on their investment (Doern and Gattinger 2003). Where the potential for participants to exercise market power exists consumer protection is also a minimum requirement. Achieving reasonable price stability in concert with ensuring the necessary investments in capacity occur is thus a key concern.

In addition to the basic elements of reliability, stability and efficiency, electricity policy and planning efforts must increasingly meet expectations for integrating environmental considerations in pursuit of sustainability. The economically optimum generation mix for instance, is unlikely to equate with its environmental counterpart. This in part means fostering flexible systems open to innovation based on a diversity of generation sources. Not surprisingly, the extent to which market competition (at least with respect to wholesale generation) is necessary to foster such elements is subject to debate.

In Dewees' (2005) view, consumers seldom pay the true cost of electricity in the absence of market prices. Fixed rates on an annual basis for instance, generally reflect the average cost of all power consumption but not the seasonal, daily or even hourly variations in marginal costs. Nor do they necessarily bear any particular correspondence with costs where for instance, severe weather events affect demand or unplanned maintenance affects supply. Again, the nature of electricity systems is important. Supply must meet demand in real-time and more expensive (and in some cases more polluting) forms of generation may be required to meet peak demand. Where pricing systems enable consumers to pay the true cost of production, the opportunity exists for consumers to adjust their consumption; provided consumers have access to the necessary information regarding prices and the system operator has information regarding consumption levels at different times. In practice this requires so-called smart or interval meters to bridge the information gap.

Making customers pay the true costs of electricity has potentially important implications for both efficiency and sustainability. Such information is likely to lead to system loads much more responsive to prices. When prices climb as load increases, some consumers will be capable of altering their consumption, thus contributing to a smoother demand profile (i.e. less variation between baseload and peak demands). Lower capacity demands means less potentially expensive and polluting energy sources are put in to use. Moreover, it reduces the necessary capital requirements for meeting demand. As Dewees' (2005) suggests, if prices remain high, consumers will adjust accordingly until the necessary capacity investments increase supply thus lowering prices. New generation and transmission capacity however, is expensive and creates potentially significant environmental impacts and land use issues that are best avoided if possible. Still, the structure of the energy supply, the sources available, the speed at which private capital is able to bring new generation capacity online, and the willingness or ability of consumers to pay high prices remain crucial.

An important caveat accompanies the assertion that marginal cost pricing will lead to socially optimal prices, that is efficient electricity production and consumption is achieved through marginal cost pricing only in the absence of externalities and transaction costs (Joskow and Schmalensee 1983). Therefore, the means through which externalities are accounted for (if at all), the extent of transaction costs will influence the ability of marginal cost pricing to realise socially optimal electricity production.

As a counterpoint to many of the above arguments, certain evidence suggests that an appropriately regulated monopoly service can be preferable to a completely liberalised supply market (Newbery and Pollitt 1997; Green and McDaniel 1998; Newbery 2002). Restructured markets are often accompanied by regulated prices and/ or investments as well as new rules concerning transmission and distribution and the proliferation new institutions such as the market operator with implications for transaction costs (Schott 2005). Prices on the market may in fact turn out to be higher than in a regulated monopoly (Patterson et al. 2002; Dewees 2005).

Price reforms are also possible in the absence of full liberalisation such that they reflect the full costs of production (and ensure investment), as well as the marginal costs at different locations and times. Still, allocating the costs of access to the transmission network between generators, the networks and users remains difficult (Patterson et al 2002).

The ability of liberalised energy markets to create sufficient investments in capacity is increasingly being questioned as many jurisdictions are facing problems of insufficient capacity, with aging infrastructure in need of upgrades and replacement (Patterson et al. 2002; ARP 2007). Schott (2005) suggests long term investment planning for capacity is a key ingredient for sustainable electricity supply. Recent experience has seen a return to Integrated Resource Planning – a modified cost-benefit analysis involving comparisons between alternative investments in energy supply and energy efficiency for meeting demand – previously thought to have peaked in the 1980s prior to the liberalisation wave which swept through much of the industrialised world during the 1990s (OPA 2005). The basic elements of IRP consist of:

- Identification of planning objectives.
- Forecasts of gross energy service demands.

- Identification of supply- and demand-side management options, that together equal the forecasts of gross energy service demands.
- Characterisation of supply- and demand-side management options in terms of their economic, social and environmental attributes.
- Creation of alternative portfolios of supply- and demand-side management options, each portfolio representing a particular set of preferences toward certain supply- or demand-side management options
- Multi-attribute trade-off analysis leading to the selection of the preferred investment/ program portfolio; analysis includes social, economic and environmental objectives but may include additional objectives such as minimisation of the risk of dramatic price increases.
- An action plan to implement the preferred investment/ program portfolio

  (Jaccard and Mao 2002).

Restructuring efforts have also posed issues with respect to innovation. As discussed, the unique technological aspects of electricity render it a unique commodity. The technological configuration arose because of the economies of scale that were present with the initial technologies. Under traditional structures equipment manufacturers, monopoly providers and government agencies pursued extensive research and technological development (R&D) programs. As liberalisation efforts proceeded, R&D was often cutback. Although such cutbacks were used to criticise the negative impacts of liberalisation, proponents of liberalisation countered that much of the R&D funding was squandered on projects that never achieved commercial viability. As such, the nature and extent of various responsibilities for R&D relative to generation and transmission in liberalised markets remains a critical question (Patterson et al. 2002). Moreover, innovative technologies must compete with tradition technologies which benefitted from the previous years of government support. As Patterson et al. (2002) state:

> Policy on technical innovation must therefore establish the kind and degree of support that government should offer to innovative electricity technologies, even in a liberalised market context. This becomes yet more pressing when innovative but immature technologies appear likely to offer major public benefits, social and environmental, and to further the aims of sustainable development.

The return to IRP suggests that public agency planning efforts will continue to play an important role in the electricity system development. Integrating social, economic and environmental objectives are clearly important to this process. In which case, insights from the sustainable development literature may prove useful.

2.2 Energy and Sustainable Development

Despite its prominence on the international agenda and amongst numerous national and international agencies, sustainable development remains complex and contested with numerous perspectives on the substance of its meaning and how to translate the concept into meaningful policy. The widely accepted Brundtland Commission's (1987) definition of sustainable development – that which meets the needs of present generations without compromising the ability of future generations to meet their own needs – suggests an inherent balance between present and future needs for human development that respects the social, economic and environmental dimensions of developmental needs. This includes environmental protection, improving the welfare of the world's poorest and most vulnerable citizens, and increasingly, enhancing public participation in decision making with respect to environmental and developmental matters. Participation as recognised in the United Nations Economic Commission for Europe's (1998), *Convention on Access to Information, Public Participation in Decision-Making And Access to Justice in Environmental Matters*, better known as the Aarhus Convention. In the context of global climate change, sustainable development has also been particularly concerned with the ability of global life support systems to sustain their critical functions (Sathaye et al. 2007).

It is clear the nature and extent of the challenge implied by attaining sustainable development is considerable. Sustainability and sustainable development in a broad sense will undoubtedly require a variety of changes in a multitude of areas in order to effectively decouple growth and development from its hitherto inescapable negative environmental implications (OECD 2001). The magnitude of the changes required to effectively mitigate and adapt to climate change poses enormous challenges. The uncertainty that pervades and influences choices of mitigative and adaptive courses of action suggests that linear strategic planning models may not be adequate for addressing this complex dynamic challenge. All of which raises questions regarding the degree to which public institutions are capable of intervening to orient and influence development in the direction of sustainability. Still, to the extent that sustainable development entails “reorienting the development trajectory so that genuine societal advance can be sustained”, it remains a worthy pursuit (Meadowcroft 2007)

Energy is an indelible component of sustainable development. Energy issues permeate many other policy areas on a global scale including security, poverty, biodiversity, and health (UN 2002). The ability of energy to contribute towards sustainable development is broadly recognised; however, crafting the delivery of energy services in such a manner that promotes growth that respects ecological boundaries and the needs of future generations remains a challenge.

For many of the world`s poorest citizens, the absence of access to basic energy services severely limits their ability to improve their living standards. Where traditional forms of biomass are used for heating and cooking purposes for instance, particulate matter threatens human health to the extent that their use (i.e. burning) within poorly ventilated areas is among the most significant causes of mortality and morbidity for women within the poorest developing countries (Johansson and Goldemberg 2002). Even where access to commercial energy services predominates, the negative environmental implications of fossil fuel combustion such as acid deposition and climate change threaten ecological systems and human health. The following sections provide an overview of the social, economic and environmental dimensions of sustainable energy systems with a particular focus on the industrialised context.

2.2.1 Social aspects of energy systems

Electricity systems provide illumination, motive power, enable communication and perform a multitude of other functions and services for society. Access to electricity at an affordable price is an essential social consideration. Likewise, the stability of prices, i.e. the avoidance of volatility is a very important concern for many individuals.

Socially responsive electricity systems must also engage civil society as well as the general public in decision making. The flexibility of, and ability of electricity systems to respond to changing preferences is an important social dimension of modern energy systems. The impacts of energy developments have the potential to influence local communities in several ways depending on the nature of the development. Wind energy developments for instance, have faced considerable local opposition in many cases due to perceived negative visual impacts on the landscape. Moreover, public health and safety issues are also an important concern for many individuals and communities who may find themselves located in the vicinity of for instance, coal-fired or nuclear generating stations. Conversely, electricity sector developments also hold the potential to offer employment and local development opportunities with the potential for positive social outcomes. In cases where electricity sector developments offer employment opportunities, worker safety is also an important issue. In which case, the social elements of electricity systems have important linkages with the economic aspects.

2.2.2 Economic aspects of energy systems

Delivering electricity at affordable prices is an inherently economic consideration. In this respect, economic efficiency is critical. Optimising two key factors of production, capital and labour, is critical to realising the optimal level of generating capacity (Schott 2005). The nature of modern electricity systems requires substantial investments in the infrastructure and technology associated with generation, transmission and distribution. Likewise, the pursuit of sustainability also necessitates substantial investments in research and development. In which case efficient systems should be able to effectively generate and allocate the necessary resources to serve these short and long term functions.

The price received for energy is a key determinant of the ability to make and sustain the necessary investments. Adequate returns based on prices should cover the marginal operating costs as well as the marginal capital costs as a minimum requirement for the economic aspects of sustainable electricity systems (Schott 2005). Different generation technologies however, are more or less well suited to meeting baseload or peak demand. Different technologies associated with the various sources of energy each have their own unique cost profiles. As such, the dynamics of the electricity system in question, its demand characteristics and existing infrastructure will all influence the mix of resources (financial or otherwise) necessary to meet demand now and in the future.

Prices however, also have important dimensions associated with consumer behaviour at household, commercial and industrial scales. Consumers have understandably strong aversions to price volatility. Still, requiring consumers to pay the real price for electricity can be an important influence on demand. Electricity is also an important element in many industries such that price paid for electricity service provision has broader implications depending on the energy intensive nature of the economy in question.

2.2.3 Environmental aspects of energy systems

Modern energy systems interact with the natural environment in several ways largely dependent upon the nature of demand, the structure of the system, the supply options available and fuels they use, as well as the wastes generated. In the case of electricity systems for instance, large hydropower generation stations disrupt ecological systems. Likewise the transmission networks connecting large generating stations with users are also ecologically disruptive on the landscape.

The atmospheric emissions (i.e. waste) associated with fossil fuel combustion create negative environmental impacts at a number of scales. On a global scale, the negative environmental implications of climate change associated with greenhouse gas emissions are considerable (IPCC 2007a). At regional and local scales, acid deposition and the generation of ground level ozone (smog) negatively impact human health, and ecosystems as well as water and soil quality. Likewise, the combustion of domestic, commercial and industrial waste for the electricity generation purposes also creates atmospheric emissions and solid wastes that are potentially toxic and must be dealt with appropriately.

There are also risks associated with nuclear power generation. Although the risk of accident has been reduced to very low levels, the size of the potential hazard remains large. Treatment of radioactive waste generated in the course of production is also unresolved as no long term permanent means for storage or containment is currently in place. The extremely long life of such wastes creates a burden for future generations.

2.3 Towards sustainable electricity systems

In 1987, the World Commission on Environment and Development (Brundtland Commission) identified four elements of sustainable energy:

1. Growth of supply to meet human needs through access to basic energy services;
2. Efficiency and conservation, minimising waste of primary energy sources;
3. Addressing public health and safety issues which arise in the delivery of modern energy services; and
4. Protection of the global biosphere as well as pollution prevention at local and regional scales.

Although the contribution of energy towards sustainable development remains important, the corollary of this equation suggests the development of sustainable energy systems is also vital. For industrialised economies, Morrison (2005) breaks down the sustainable energy development problem into two key challenges facing policy-makers:

1. *Meeting demand*: providing reliable and affordable energy services to all segments of society in a manner that contributes to the socio-economic well-being of individuals and society at large;
2. *Minimizing impacts:* delivering energy services in a manner that does not undermine the social and ecological systems modern societies rely upon.

That is, if social and environmental aspects are important elements of modern energy systems, it is necessary to incorporate their value into decisions, now and into the future. In the context of industrialised economies' electricity regimes, the above issues coalesce around three basic elements:

1. Reliability;

2. Efficiency; and,
3. Environmental impacts.

A sustainable electricity system must be capable of reliably delivering electricity to where it is needed when it is needed as a minimum requirement. Secure access to primary sources of energy in adequate quantities over time is therefore essential. Lessening the environmental burden created through the delivery of electricity – and the services it provides – is also a key consideration. The ability to establish and coordinate the necessary investments in a timely fashion is further critical to ensuring reliability. As noted, efficiency is a key consideration in this respect and so too is the structure of the energy supply.

The ability to deliver ever greater services from an equivalent amount of energy has significant social, economic and environmental implications. The efficient delivery of energy services at a system level has important impacts on cost-effectiveness and price stability. Greenhouse gas emissions, import dependency, air pollution, price volatility, and industrial competitiveness are all functions of demand. As noted, economic growth and demand for electricity are linked. Although energy policy does not have the capacity to influence economic growth as such, it has a critical role to play in moderating or limiting this relationship such that energy demand growth is decoupled from its economic counterpart. As such, energy efficiency efforts are commonly a focal point of sustainable energy strategies (Alanne and Saari 2006).

The structure of electricity supply infrastructure is possibly the key determinant of its environmental impact. Renewable sources and advanced technologies (e.g. CO_2 capture and sequestration, fuel cells) capable of delivering electricity without for instance greenhouse gas emissions are key elements. At the same time, the proximity of renewable supply sources to locations of end use consumption is also important such that requirements for extensive transmission networks may negate or moderate their environmental benefits associated with their development. Moreover, different resources have different life spans and impacts associated with their construction, operation and end of life. In which case, it is important to account for all of the negative externalities associated with the development of supply resources throughout the entire life-cycle of the resources in development.

Alanne and Saari's (2006) definition of a sustainable energy system summarises many of the above elements:

> a cost efficient, reliable and environmentally friendly energy system... effectively utilises local resources and networks....flexible in terms of new techno-economic and political solutions. The introduction of new solutions is actively promoted.

In many ways it is the latter part of this definition which encapsulates the fundamental challenge of developing sustainable energy systems. The flexibility to respond to new challenges, innovations (both technical and political), and knowledge is paramount. Not only must electricity systems be capable of responding to changing circumstances over multiple time scales but they must also actively seek the development and acquisition of solutions needed to overcome challenges. Facilitating and accelerating the uptake of renewable sources of primary energy for instance, as well as technologies that enhance efficiency and reduce emissions are clearly important dimensions of sustainable energy. Such concerns are reflected in the policy implications arising from the conclusions of the Accelerated Technology (ACT) scenario analyses performed by the International Energy Agency (2006) which suggest "energy efficiency is top priority; well-focused R&D programs are essential; the transition from R&D to technology deployment is critical; governments need to create a stable policy environment that promotes low carbon energy options; [and] non-economic barriers must also receive attention."

To return to Brundtland`s definition of sustainable development, the balance between short and long term needs (i.e. meeting demand while minimizing impacts) is fundamental. Sustainability requires the equitable distribution of resources necessary to not only meet needs but also take advantage of opportunities. In practice, this requires a balance between investments expected to generate immediate dividends, and those where benefits may be realised over longer time frames such as research and development.

In pursuit of solutions, electricity regimes must also be open to changes that may alter the institutional (e.g. regulation), economic (e.g. patterns of investment), and cultural (e.g. user preferences) configurations that comprise modern energy systems. Many of the non-technical aspects of modern electricity systems have changed substantially through restructuring efforts oriented towards the introduction of private sector competition and greater efficiencies associated with market driven programs. Still, Johansson and Goldemberg (2002) suggest there are three key reasons for public intervention:

1. The inseparability of social and economic progress from access to modern energy services.
2. Natural monopoly characteristics of some elements of the energy system, such as electric grids, exclude competition as a means to achieving economic efficiency.
3. Significant negative environmental and social impacts (local and global) of energy use that are not reflected in energy prices.

Accounting for the negative social and environmental impacts of energy use is now at the core of energy policy within many industrialised countries. To be sure, cost efficiency and reliability remain fundamental; however, the critical challenge of balancing traditional goals associated with social and economic progress against their negative external implications remains. In the context of modern, liberalised electricity sectors, a crucial aspect of sustainable energy development entails coordinating investments which facilitate the development of supply infrastructure in appropriate combinations that respect the environmental dimensions of sustainable development.

It is clear that orienting energy systems towards sustainable development is a complex process. The ability to overcome uncertainty by learning from actions is important. Sustainable energy development is unlikely to occur in the absence of some form of public intervention, especially where facilitating investment in a balanced portfolio of supply resources is concerned. To the extent that sustainability provides orientation rather than a concrete decision criterion, it is worth considering the means through which sustainable electricity development is pursued.

The remainder of this analysis will be devoted to examining these issues through an empirical analysis of an electricity sector in Ontario, Canada. In this vein, rather than attempt to ascertain whether or not the electricity system is in fact efficient and/ or environmentally sustainable, it will seek to assess the means employed in the strategic pursuit of a sustainable electricity system focusing on reliability, efficiency, and environmental impacts. The analysis will concern itself with the means through which these elements are sought, improved and integrated in pursuit of a sustainable electricity system.

3. Electricity in Ontario

The challenge facing the electricity system in the Canadian Province of Ontario appears straightforward. Much of the existing electricity generation infrastructure (and nuclear in particular) will reach the end of its life within 20 years. The seeming simplicity of this equation however belies the complexity of the challenge. Although substantial investments in infrastructure are clearly needed, the challenge is more complex than merely constructing new capacity to meet demand. Measures to reduce demand are essential. Social and environmental dimensions must be respected and integrated.

Ontario's electricity system has undergone substantial restructuring over the last ten years. As the electricity system shifted from a centralised monopoly to an open market structure between 1998 and 2002, new institutions were created and roles shifted to facilitate more competitive markets for wholesale and retail electricity supply. Yet, dissatisfaction with the market system – as it was constructed – led to further revisions resulting in what is now considered a "hybrid" market for electrical power generation with significant elements of planning and control on the part of public agencies.

The commencement of an integrated planning exercise in 2005 represents a fundamental turning point in the history of Ontario's electricity sector.[6] It represents a unique opportunity to orient the development trajectory for Ontario's electricity system along a more sustainable path. In this respect, the language within the Ontario Ministry of Energy's (2007) Results-Based Plan is instructive. Nearly 90% of ministry spending occurs through its Energy Sector Transformation strategy in support of its mandate to "support the development

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[6] A comprehensive, integrated planning exercise for the province's electricity system was last completed in 1990

of a cost-efficient, reliable and environmentally sustainable energy supply, while at the same time creating a culture of energy conservation" (MoE 2007). In short, the focus of Ministry efforts is to transform its current system towards sustainability.

In striving to realise this transformation for the electricity sector, an integrated planning exercise has been chosen as the means to sustainable ends. To the extent that the future is inherently uncertain, it is worth questioning the extent to which planning can achieve the strategic change that sustainability requires. On a basic level, the purpose of planning is to realise a particular outcome or set of outcomes. Yet, social perspectives on what constitutes a desirable outcome may differ substantially in the future compared with current perceptions. Maintaining options and enabling flexibility for future generations is therefore paramount, especially in the context of efforts to realise sustainable energy development.

Still, electricity remains an essential service within industrialised economies. System reliability is an essential condition, and the costs of service provision have both social and economic implications, particularly in the short term. In which case, efforts to transform the electricity system must ensure the transition period does not result in significant social and economic dislocation. How planning deals with the basic dilemma of constructing a long term sustainable electricity future in the context of inherent uncertainty, subject to this short term stability constraint is thus crucial.

This section will briefly outline the historical development of Ontario's electricity system, and the institutions which govern it. It provides context for the current challenges facing the system, as well as the plan developed to guide Ontario towards a more sustainable electricity future.

3.1 Background to Ontario's Electricity Regime

Commercial electricity systems are an inherent element of industrialised economies. The corollary of which means the status, and structure of the industrialised economy in question maintains a vital influence on the electricity system. Patterns of demand are linked with patterns of economic and population growth. In Ontario, economic recession during the early 1990s, coupled with industrial restructuring related to the Free-trade Agreement between the United States and Canada (and later Mexico under the North American Free Trade Agreement) substantially reduced demand. During this time, Ontario Hydro (the former integrated monopoly service provider) was faced with considerable excess capacity and substantial debt servicing costs (largely associated with recently constructed nuclear generation facilities). In the face of reduced revenues – much of which went to interest on debt – Ontario Hydro was forced to reduce costs, both operating and capital. Staff was reduced, and many investments in supply and transmission infrastructure were eliminated (OPA 2005).

It is within this context that interest in restructuring Ontario's electricity sector evolved. Following the broad currents of electricity policy change occurring elsewhere throughout the industrialised world, the government introduced plans for moving towards a more liberalised and competitive market for generation with the introduction of the *Electricity Act, 1998* which:

- Established a market for wholesale and retail competition on May 1, 2002;
- Separated and commercialised transmission assets (now operated by Hydro One Networks Inc.) from generation assets (now owned by Ontario Power Generation) as well as commercialised municipal utilities (now referred to as Local

Distribution Companies) to permit non-discriminatory access to the transmission network for all market participants;

- Created an Independent Market Operator (now Independent Electricity System Operator) with responsibility for managing the operation of, and ensuring the reliability of Ontario’s electricity system on a short term (i.e. daily – 18 months) basis, including wholesale market administration;
- Expanded the mandate of Ontario Energy Board (provincial regulator) to license and regulate market participants and associated projects in protection of the public interest.

Under this system markets were the primary mechanism for coordinating the establishment and construction of the new supply infrastructure. Market opening however was fraught with price volatility and higher than expected costs due in part to an unusually hot summer (i.e. increased demand), and the unfortunate fact that several generation stations were temporarily out of service (Dewees 2005). Four months after market opening, the Independent Electricity Market Operator (2002) released a report with several startling conclusions:

- available excess capacity (to meet summer peak demand) declined from 19.2% to -1.5% between 1996 and 2002, with Ontario dependent upon imports to meet peak summer demand since 1998; and
- Ontario had a growing capacity shortage in the face of growing demand, threatening system reliability and creating upward pressure on prices during times of peak demand.

In response to growing consumer unrest, a price cap was imposed on retail electricity prices for most small consumers (accounting for ~50% of consumption) approximately six months after market opening (Trebilcock and Hrab 2005). Fixed rates for the transmission and distribution were also instituted, while wholesale competition remained. Dewees (2005) is highly critical of the retail price cap arguing it discouraged: (i) competitive electricity retailing (not possible to compete with price cap); (ii) conservation (eliminating the price signal); and, (iii) investment in new capacity. As the OPA (2005) notes: “the net result was a complete cessation of new investment in generation”.

In the absence of new investment, growing demand eventually eliminated the excess capacity that had existed during the early 1990s. As the nature of the supply shortage became recognised, the government appointed an Electricity Conservation and Supply Taskforce (ECSTF) to examine how the supply gap should be addressed. Several key recommendations of the final report are particularly relevant:

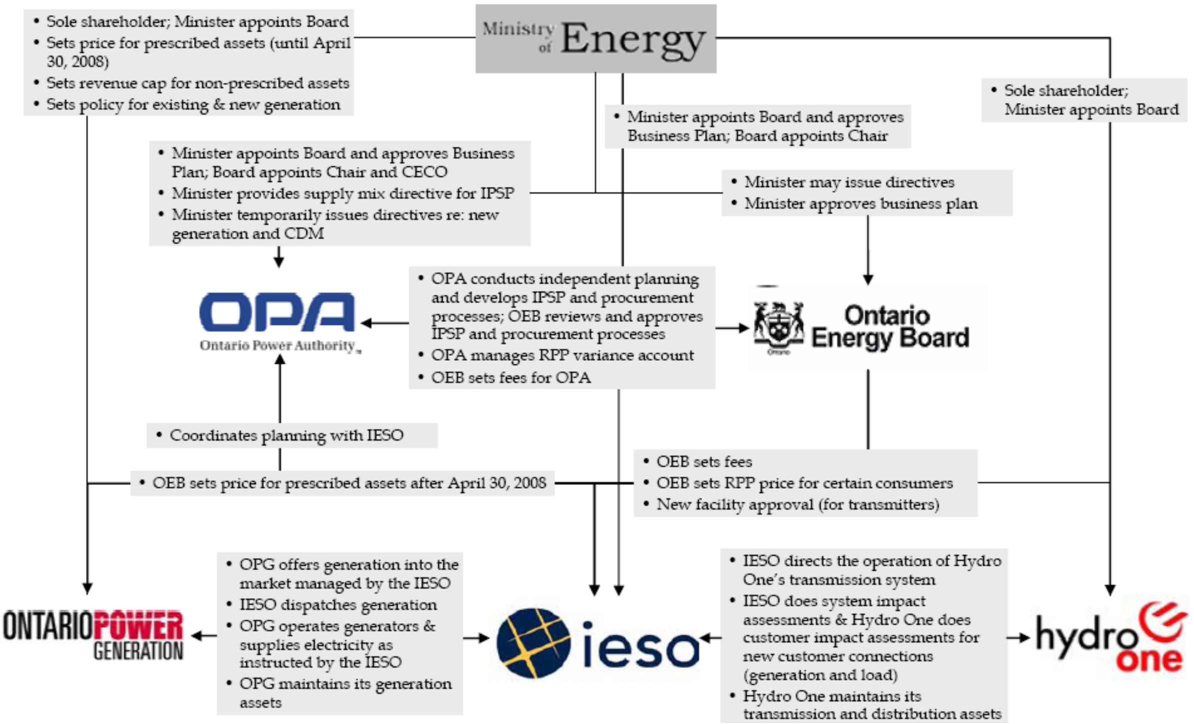
- Creation of a long term planning function to prepare Integrated Power System Plans for the purposes of guiding and coordinating the development of demand, supply, and transmission resources;
- Establishment of an office for examining, advocating, and facilitating electricity conservation;
- Establishment of a procurement process that ensures cost recovery for investors in new generation capacity;
- Guidance from government on the preferred combination of electricity resources to meet the province’s needs, particularly in respect of environmental criteria and the diversity of supply sources (ECSTF 2004).

In response, the *Electricity Restructuring Act, 2004* was introduced. Through amendments to the *Electricity Act, 1998*, it established the current institutional and regulatory framework within which market forces and central planning coexist. The current system of public agencies, regulators, and corporations tasked with providing planning, management, oversight and operation for the province's electricity system are outlined in Figure 3.1 including:

> *Ontario Power Generation Inc.*, (OPG) a provincially owned corporation responsible for the generation of nearly 70% of provincial electricity needs;
>
> *Hydro One Inc.*, a provincially owned corporation who owns and operates nearly the entire provincial transmission network, as well as provides local distribution services in many cases;
>
> *Independent Electricity System Operator (IESO)*, the government agency responsible for the reliability and operation of the electricity system in the short term and real-time, with particular responsibility for the wholesale market. Monitors, investigates and reports on market behaviour and activities, and is also responsible for enforcing standards on reliability.
>
> *Ontario Power Authority* (OPA), the government agency responsible for long term planning including the procurement of new supply as well as conservation and demand-side management.
>
> *Ontario Energy Board* (OEB), the provincial regulator. It regulates electricity and natural gas industries, as well as local distribution. The OEB is also responsible for the approving the integrated power system plan, and approving the process for procuring new supply, both of which are prepared by the OPA.

Again, only the OEB existed prior to the electricity system restructuring that took place in 1998, where all of the functions (save that of the OEB) were previously served by the provincial monopoly, Ontario Hydro. The other institutions (except the Ontario Power Authority) were all established at that time.

Figure 3.1 Roles and relationships of public authorities within Ontario's electricity regime



Source: ARP 2007

The key outcome of the 2004 restructuring efforts was the establishment of the Ontario Power Authority (OPA), as a provincial agency with responsibility for four key areas: power system planning, conservation initiatives, development of generation capacity, and electricity sector development.

Power System Planning consists of medium- and long term assessments as well as the development of 20-year Integrated Power System Plans, which must be updated every 3 years on a rolling basis to ensure a continuously updated, responsive and evolutionary planning effort occurs in adherence with *Ontario Regulation 424/04* under the *Electricity Act, 1998*. Under Section 25.30 of the *Electricity Act, 1998* the Minister of Energy has the authority to issue directives that establish goals for the power system planning process in the following areas:

a) the production of electricity from particular combinations of energy sources and generation technologies;

b) increases in generation capacity from alternative energy sources, renewable energy sources or other energy sources;

c) the phasing-out of coal-fired generation facilities; and

d) the development and implementation of conservation measures, programs and targets on a system-wide basis or in particular service areas.

Conservation initiatives are under the direction of the province's Chief Energy Conservation Officer who heads the OPA's Conservation Bureau.

Development of Generation Capacity occurs through procurement processes for investment in new generation capacity, as well as conservation and demand management initiatives. Although the opportunity exists for generation capacity to be established solely upon private investor initiative, in the existing policy context, procurement – and the certainty that such a contracting function provides – is critical for adding the necessary capacity.

Electricity Sector Development concerns the management of electricity prices. In this regard the OPA's aim is to modulate price volatility while simultaneously assuring the full costs of electricity are recovered.

Of all these functions power system planning holds the key to Ontario's electricity system, with considerable influence over the other functions. Prices are ultimately reliant upon the resources available for dispatch to meet demand, and although the Conservation

Bureau plans, coordinates and delivers programs, the conservation and demand management targets used within the planning process have important implications for what other resources are deemed necessary. Likewise, procurement for new generation resources will occur in the context of the necessary resources as determined via the integrated power system planning process.

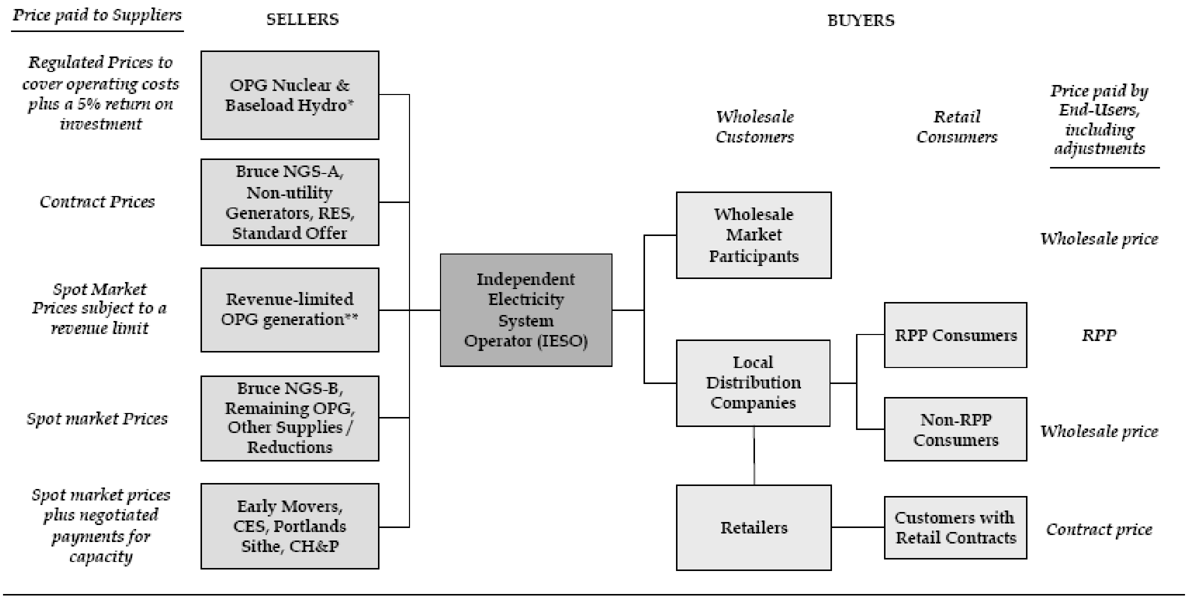
Despite the planning responsibilities bestowed upon the OPA, it does not maintain the ability to exert centralised control with respect to plan outcomes. Much has changed since the last integrated power was produced. Its partners in establishing generation capacity are commercial entities and market forces play an important role in the ability of the plan to realise its targets. The OPA must also cooperate with a group of other agencies tasked with ensuring the public interest is served over both the short and long term. It must strive to develop an integrated plan capable of coordinating action where control over its implementation is distributed across a range of actors.

Presently, centralised planning coexists with market forces within what is termed a “hybrid” market for electricity (Figure 3.2). Much of the electricity generated in Ontario is bought and sold at administratively determined prices, although in some cases, electricity is bought and sold at real-time or “spot” market prices. In the case of the spot market, the IESO accepts offers from generators to produce electricity at a certain price, with the spot market price equal to the price offered by the last unit of generation (i.e. the most expensive) needed to meet demand at one particular time. This price is reset every five minutes based on the prices offered by generators. A weighted average price for each hour is then determined (the Hourly Ontario Electricity Price) which is the wholesale price for generation.

In contrast with the spot market, prices paid for electricity generated from assets owned and operated by Ontario Power Generation (OPG) are regulated to prevent the exercise of market power. Although the spot market exists, not all generators will typically receive the spot market price. Rather, they may enter into power purchase agreements (PPAs) which guarantee a price (or price range) for the generator's output.

Adjustments are also made on the consuming side of the equation with wholesale buyers (i.e. industry) and local distribution companies paying the spot market price initially, and consumer prices adjusted to balance the amounts paid to generators. Retail customers are also eligible to participate in the Regulate Price Plan (RPP) which sets guaranteed rates for six month periods with the aim of protecting consumers from price volatility.

Figure 3.2 Ontario's hybrid market structure for electricity



Notes:
Bruce NGS-A and B are at the Bruce nuclear generation station, owned by OPG and operated under lease by Bruce Power.
Early movers and Sithe are private-sector generators.
Portlands is a partnership of OPG and TransCanada Pipelines

CES = Clean Energy Supply
CH&P = Combined Heat & Power
NGS = Nuclear Generating Station
RES = Renewable Energy Supply

Source: ARP 2007

In addition to coordinating and engaging with private actors and public agencies, the OPA must account for the fundamental challenge of uncertainty concerning how future events will unfold. Demand projections and rates of technological development are inherently uncertain. As the events of the 1990s demonstrate, macroeconomic factors can play an important influence on electricity systems. Recognising the imprecision associated with forecasting over long times spans, the OPA suggests only the first three years of any IPSP should be considered "prescriptive" and emphasises that immediate action that should be taken to meet short term needs as well as preserve options for the future (OPA 2005). Approaches to addressing uncertainty in the short term may need to differ from those which must address long term challenges. Particularly if Ontario is to avoid establishing the considerable excess capacity that has resulted from previous centralised planning efforts in the province and elsewhere.

As the preceding discussion indicates Ontario's electricity regime is characterised by substantial public intervention but with certain elements of liberalisation persisting. Building on Jaccard and Mao's (2002) analytical framework for characterising government intervention in the electricity sector, several characteristics are noticeable with respect to: (1) ownership of assets; (2) investment and resource planning; (3) price setting for electricity; and (4) the market-orientation of regulation.

Although 70% of Ontario's electricity is generated through assets owned and operated by Ontario Power Generation (owned by the provincial government), new generation assets will increasingly be developed by private companies. Still, OPG is operated as a private corporation with a Board of Directors entrusted with responsibility for ensuring accountability with respect to major investment decisions. Likewise, the transmission network is owned and operated by a private corporation owned entirely by the provincial government. In a similar manner, an independent Board of Directors is in place to ensure accountability while the public good character of the transmission network is preserved.

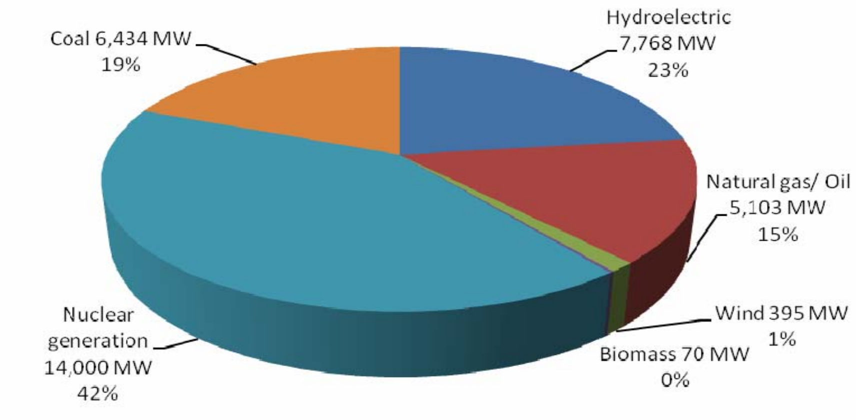
As indicated a hybrid market for electricity pricing exists where regulated pricing plays an important role in many cases with regulated prices designed to ensure the full costs of delivering electricity are recovered. Differentiated pricing for instance is a key element of regulated prices. Similarly, investment planning occupies a type of middle ground where the OPA determines which resources in which combination will provide the electricity generation infrastructure, yet private entities will ultimately construct generation infrastructure in response to procurement initiatives.

Despite private sector involvement in developing infrastructure, the infrastructure developed is ultimately a function of the outcomes of the IPSP which directs procurement. In the context of sustainable energy development, Jaccard and Mao's (2002) framework suggests three approaches for addressing negative externalities: minimal government intervention (e.g. externality taxes); market-oriented regulation (e.g. cap and trade); and improved regulation and planning. The approach used is largely a function of the extent of government intervention. As such, the substantial intervention which characterises Ontario's electricity system constrains the ability to employ market oriented regulation for addressing externalities. In which case, regulation and planning are the primary vehicles for addressing externalities within Ontario's electricity system.

3.2 Ontario's Electricity Challenge

In 2007, Ontario's installed generation capacity was equal to approximately 35,000 MW although the available operational capacity is effectively less than 29,000 MW (ARP 2007; Figure 3.3). Unplanned for outages, regular shut-downs for servicing of units, intermittency with certain resources (e.g. wind) and the need to retain sufficient capacity in reserve in order to meet unexpected demand increases further reduce available capacity at any one point in time.

Figure 3.3 Ontario’s installed generation capacity, 2007



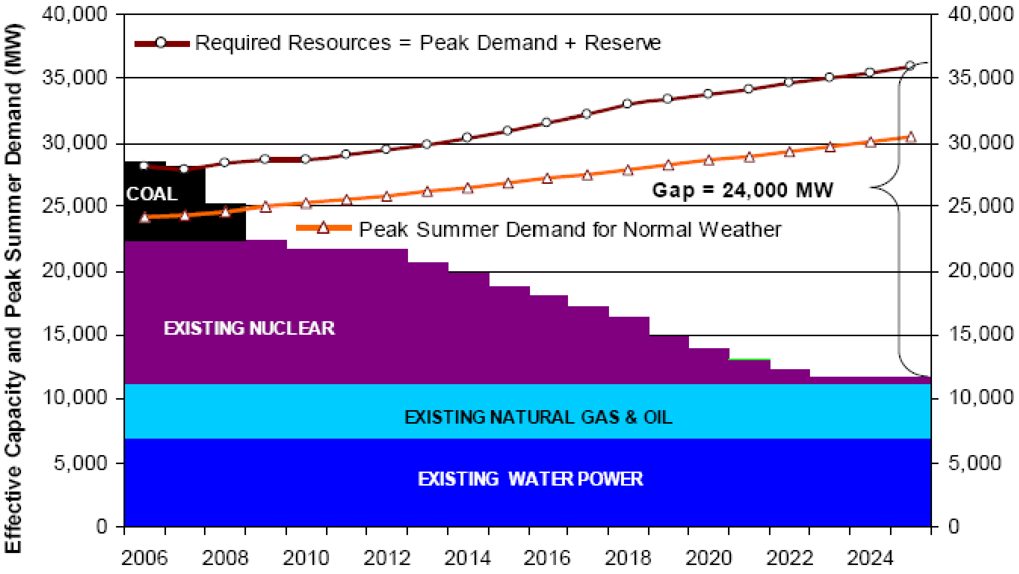
Source: OPA 2007 D-3-1

In 2007 Ontario’s peak demand (which occurs during the summer months) equalled approximately 26,000 MW (OPA 2007 D-1-1). Although supply and demand are approximately balanced much of the time, this balance is not projected to remain so in the absence of further action. Three reasons shape this equation:

1. Increasing demand associated with economic and population growth;
2. Nuclear capacity reaching the end of its life; and,
3. Retirement of coal-fired generation in lieu of a government commitment to phase out all coal-fired generation capacity in the shortest feasible timeframe.

On one level, these are infrastructure challenges. Ontario’s existing nuclear capacity will gradually reach the end of its life within the next 10-15 years. Economic and population growth are projected to continue over the course of the next 25 years resulting in increased demand for electricity of approximately 1% per year in terms of both peak demand (MW) and total consumption (TWh) (OPA 2007 C-6-1). Addressing the challenge of reducing greenhouse gas emissions through the elimination of coal-fired generation has further exacerbated the infrastructure challenge such that Ontario faces a potential 24,000 MW gap in capacity during times of peak demand (Figure 3.4).

Figure 3.4 Ontario generation requirements and forecast demand growth



Source: OPA 2005

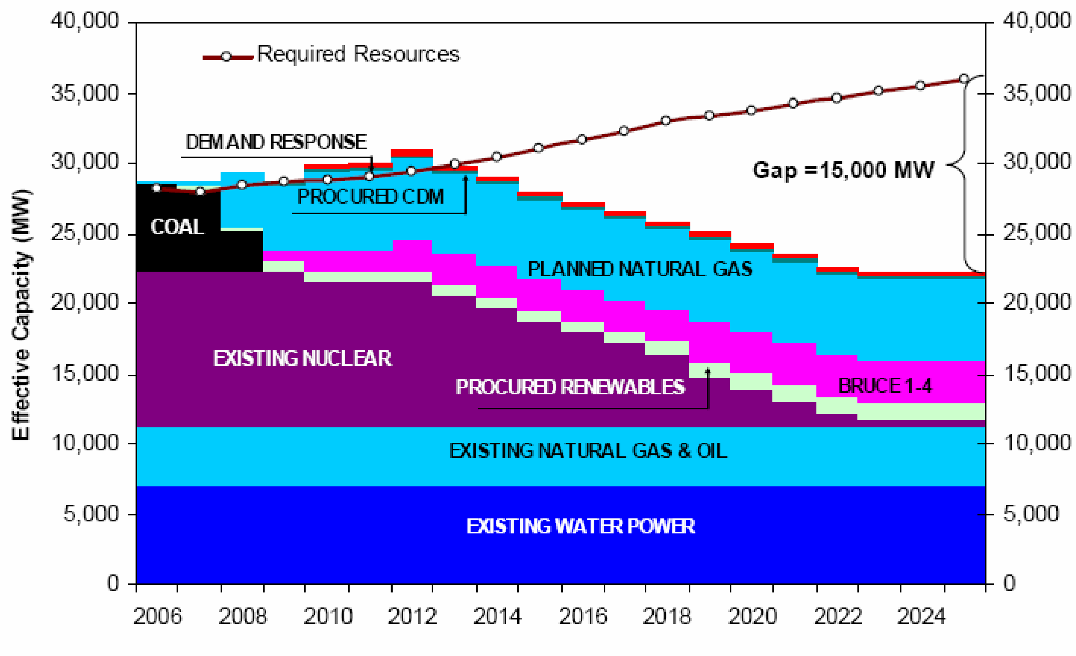
Ontario's demand profile is such that its baseload seldom falls below 50% of peak demand. Yet the base load (i.e. minimum) requirement is often much higher than 50% of peak demand. In 2007 for instance, the electricity load was forecast at approximately 62% (i.e. two-thirds) of peak demand for 72% (i.e. 8½ months) of the year (OPA 2007 D-3-1). The IPSP defines baseload capacity as the demand that exists 72% of the time. Substantial baseload resources are required. Much of the base load nuclear capacity will gradually be retired in 10-15 years and the phase-out of coal-fired generation will also remove substantial (6400 MW, 19% of installed capacity) intermediate capacity. Projected increases in peak demand suggest that Ontario will need sufficient resources to ensure system reliability. As such, Ontario will require substantial investments in all types of capacity. The challenge however, it not as simple as providing the necessary infrastructure, but rather establishing a sustainable foundation for the future development of a sustainable electricity system characterised by ever greater efficiency and reduced environmental impact.

Beyond infrastructure, Ontario's electricity system must also strive to change patterns of electricity usage (i.e. demand) and address the negative environmental impacts associated with the existing supply infrastructure. Load forecasts and demand projections vary according to fuel prices, economic growth, technological efficiency improvements, and structural changes in the economy. All of which complicate efforts to assess the potential effectiveness of conservation and demand-side management initiatives; initiatives which impact decisions regarding the necessary infrastructure that must be planned for, often well in advance. Still, moderating, minimising, and/ or eliminating demand growth is an essential element of sustainable energy development. The IPSP (2007 D-1-1) forecasts total electricity consumption will increase from 157 TWh in 2007 to 195 TWh in 2027. This represents a 24% increase. Moreover, peak demand is projected to grow by nearly 7400 MW.[7] Using existing nuclear capacity in Ontario as a simple indicator, meeting this demand growth would require the construction of approximately 10 nuclear generation units.[8]

At the same time, air pollution has increased substantially since the restructuring efforts began to take shape during the 1990s. In 2001 for instance, CO_2 emissions from electricity generation equalled 38.6 million tonnes, a 160% increase compared with 1994 (OPG 2001). Moreover, the Ontario Clean Air Alliance (2002 cited in Schott 2005) in cooperation with the Ontario Medical Association estimate air pollution is responsible for the deaths of 1800 individuals every year in Ontario. Further complicating efforts is the fact that much of the potential renewable generation capacity in the form of hydro and wind power is located at a substantial distance from population centres necessitating substantial upgrades or enhancements for the transmission network (OPA 2007 D-4-1).

In the absence of an integrated plan, Ontario has initiated a series of procurement initiatives including conservation and demand management projects targeting 1350 MW of reduced peak demand, and 2700 MW of new renewable generation capacity. Approximately 6000 MW of natural-gas fired capacity are included as well as the restart of 2 nuclear units (Bruce 1 & 2) and the refurbishment of 2 others (Bruce 3 & 4). If implemented accordingly, these initiatives are projected to ensure adequate capacity over the medium term to 2014, and reduce the supply gap to approximately 15,000 MW over the long term, and (Figure 3.5).

Figure 3.5 Ontario supply gap inclusive of existing procurement initiatives



Source: OPA 2005

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[7] Peak demand equal to 26282 MW in 2007 and projected at 33677 MW in 2027

[8] 16 Nuclear generation units currently in operation provide 11419 MW of capacity: 11419/16 = 714 MW average per unit

In summary, Ontario's is at a unique point in the development of its electricity system. The retirement of substantial capacity presents planners and policy makers with a unique opportunity to intervene in the development of the electricity system. Part of this opportunity derives from the failure of restructuring efforts to create an environment where investments in supply infrastructure could materialise. In addition, the environmental impacts of the electricity regime were greatly exacerbated. Moreover, the regime has failed to foster conservation and efficiency measures commensurate with the challenge. Nor has it lead to competition for the delivery of more efficient electricity services to consumers. In which case, it is worth examining how the planning process responds to and addresses the challenge of developing a sustainable electricity system.

4. The Integrated Power System Plan

On June 13, 2006 the Ontario Power Authority was directed to develop an Integrated Power System Plan (IPSP) according to specific direction outlined by the Minister of Energy in the so-called “Supply Mix Directive”, which directed the IPSP to contain a certain mix of supply resources (Duncan 2006). Integrated Power System Plans cover a 20 year time horizon from the date of submission and must be developed and updated every three years on a continuous basis. The IPSP for the period 2007-2027 was submitted to the Ontario Energy Board for approval in August 2007.

The IPSP provides the basis for the development of supply infrastructure. In doing so the OPA must adhere to the policy direction and targets outlined by government. Concurrent with, and integral to the IPSP, the OPA has also developed a procurement process for bringing new supply options on line. Although the procurement process is an important aspect influencing the cost associated with IPSP implementation, this analysis will focus primarily on the process surrounding the recommendations for the development of supply infrastructure. The means through which resources are procured (e.g. competitive bidding, direct award etc) are no doubt important; however, at this juncture the decisions on which supply resources will be procured are considered paramount.

This section will describe how the IPSP 2007-2027, plans for the development of a sustainable electricity system. This section will employ a modified version of Jaccard and Mao’s (2002) IRP elements as a framework for structuring this section in review of the IPSP:

1. *Planning objectives* including the scope of the planning process.

2. *Identification of supply- and demand-side management* options, including their characterisation in terms of economic, social and environmental attributes.

3. *Creation of alternative portfolios* of supply- and demand-side management options and multi-attribute trade-off analysis leading to the selection of the preferred investment/ program portfolio; analysis includes social, economic and environmental objectives but may include additional objectives such as minimisation of the risk of dramatic price increases.

Within these headings, this section will focus on outlining key elements of the plan and the factors influencing outcomes in a descriptive manner. The following section will discuss and analyse the IPSP in light of relevant sustainable electricity considerations.

4.1 Scope and Objectives

The Supply Mix Directive (the Directive) contains specific policy direction for the OPA outlining the distinct policy priorities which guide IPSP development (Table 4.1). The Directive establishes a consistent priority ordering for meeting Ontario's electricity needs: maximizing conservation efforts first and renewable resources second, prior to making new investments in conventional supply infrastructure including imports from other jurisdictions. These priorities are consistent with previous directive which instructed the OPA to prepare advice on the appropriate supply mix (Duncan 2005). Targets established for the IPSP process are derived primarily from the Supply Mix Advice Report produced by the OPA (2005). In addition to the priorities and targets regarding supply infrastructure described in Table 4.1, the Directive also required the OPA to strengthen transmission system to facilitate the achievement of the above goals, particularly with respect to integrating new renewable capacity and the promotion of overall system efficiency.

Table 4.1 Policy priorities and targets guiding IPSP development

Policy Priorities	**Target**
Maximize feasible cost effective contribution from energy efficiency, demand management, fuel switching, and customer based generation ("Conservation");	Reduce peak demand through conservation initiatives by 6300 MW by 2025 including 1350 MW by 2010. Above targets are in addition to existing initiatives established outside IPSP process which aim for a 1350 MW reduction.
Maximize feasible cost effective contribution from renewable sources;	Increase total renewable capacity to 15700 MW by 2025 including 2700 MW by 2010.
Make up baseload requirements remaining after Steps 1 and 2 above with nuclear power;	Limit in-service nuclear capacity to 14000 MW over the life of the plan
Replace coal-fired generation.... in order to ensure that existing coal-fired facilities are replaced by 2014, gas-fired generation ("GFG") facilities are planned to be installed in [three] areas[9]; and restrict contribution of gas-fired generation to specific projects as required when additional conservation and renewable resources are not feasible or cost effective.	Employ natural gas capacity to meet peak demand

Although the formal targets contained in the Directive derive primarily from the Supply Mix Advice Report, there are a few important differences. Whereas the Supply Mix Advice Report recommends 1800 MW of peak demand capacity savings through efficiency, demand reduction and response measures, the Directive requires the OPA to plan for 4950 MW of savings in addition to already announced procurement initiatives. In doing so it directs the OPA to expand the scope of conservation measures to include customer-based electricity generation including small-scale (<10MW) natural gas-fired co-generation, fuel switching, and initiatives to replace electric heating and air conditioning systems with geothermal and/or solar units. The IPSP also directs the OPA to plan for an additional 200 MW of renewable capacity compared to what was recommended in the Supply Mix Advice Report, increasing the requirement from 15500 MW to 15700 MW. Because the Supply Mix

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[9] Northern York Region, Kitchener-Waterloo-Cambridge-Guelph and the Greater Toronto Area.

Advice Report played such an integral role in the Directive this analysis will consider its contents in review of the IPSP to the extent they are relevant.

The OPA is also required to comply with the requirements as set out in legislation through *Ontario Regulation 424/04* (the IPSP Regulation). Many of the requirements align with and reinforce the policy priorities established through the Directive. In addition the IPSP Regulation requires the OPA to "consult with consumers, distributors, generators, transmitters, and other persons who have an interest in the electricity industry" and "ensure that safety, environmental protection and environmental sustainability are considered". In meeting the above requirements in a holistic manner, the OPA (2007 C-10-1) developed six specific evaluative criteria to guide organisational decision making with respect to the IPSP:

> *Feasibility*: This is comprised of technical feasibility, commercial availability, technological maturity, sufficient infrastructure and lead time and compliance with regulations, all of which must be present if resources are to be incorporated in the IPSP.
>
> *Reliability*: Resource adequacy and system security, which make up the components of this criterion, are necessary to maintain system reliability at all times throughout the planning horizon.
>
> *Cost*: This encompasses cost of options on the planning horizon, the value of conservation, cost of services to consumers and impact on customers' bills.
>
> *Flexibility:* This includes the flexibility of options in the future and the robustness of the plan to be sufficiently adaptable to a range of future scenarios.
>
> *Environmental Performance*: This includes the amounts of greenhouse gas (GHG) emissions, conventional contaminant air emissions, radioactivity, water use and wastes generated.
>
> *Societal Acceptance*: This includes the matters that have significant socio-economic implications.

The OPA is mandated to develop the IPSP through careful consideration of initiatives tackling both supply and demand, and the above criteria provide a general framework for assessing options. The IPSP is intended to help provide the “big-picture certainty that investors and other decision makers require [and] lead to better co-ordination of major projects” (OPA 2007 C-5-1). Coordination is fundamental such that the OPA (2007 C-5-1) states the: “key purpose of planning is to guide the actions of many different and diverse electricity system participants.”

4.2 Options Identification

The following sections will outline the means through which supply- and demand-side management options were identified. In keeping with the policy priorities outlined above, this section is further subdivided on the basis of conservation, renewables, and conventional resources.

4.2.1 Conservation

Maximising the feasible cost effective contribution from conservation occurs through four types of conservation and demand-side management initiatives: (i) energy efficiency, (ii) demand management, (iii) customer-based generation and (iv) fuel switching. In addition to reducing consumption through the use of more energy efficient equipment and buildings, demand management initiatives aim to encourage consumers to shift their consumption away from peak hours and/or reduce consumption during such times. Reductions may be voluntary, in response to high prices, or they may occur as a result of contractual agreements where for instance, industrial customers agree to shut down production under certain conditions. Customer-based generation refers to customers installing generation facilities (e.g. combined heat and power, small scale renewables) to meet their own needs. Fuel-switching refers to customers replacing electricity consuming equipment with equipment that uses other energy sources such as replacing electric baseboard heating with a geothermal system.

Opportunities for conservation were first identified on a system wide level and then subdivided according to their potential contributions to meeting base load, intermediate and peaking resources needs. The first step aligns conservation activities with demand projections while the second facilitates comparison with alternative supply resources capable of meeting various system requirements. With potential savings identified and allocated, the programs necessary to realise savings were developed thus enabling an evaluation of net benefits.

Estimating potential opportunities on a system wide basis occurred through a variety of methods examining various scenarios for efficiency, demand management, customer generation, and fuel switching. Such estimates were generated on the basis of potential saving from the residential, commercial and industrial sectors. Energy efficiency estimates for example, were first estimated using an end-use model that estimates demand through simulating replacements and additions of energy consuming equipment. The modelling exercise was supplemented with a market scan of the industrial sector in order to account for additional efficiency gains associated with process changes as new technology is introduced.

Primary responsibility for conservation is allocated to energy efficiency and demand management. The IPSP plans for 65% of the 2025 peak demand reduction target to be met through energy efficiency and 20% from demand management, with the remaining 11% from customer generation and 4% from fuel switching. Similar plans are present in the short term for customer generation and fuel switching, with efficiency and demand management’s planned contributions equalling 44% and 40% respectively, of the total reduction for the period 2008 to 2010. The substantial allocation towards energy efficiency and demand management initiatives is a result of both experience with, and the availability of information on such conservation types. Although the available data and market information suggest these initiatives have the greatest potential, substantial experience with such initiatives also provides a high degree of reliability that the conservation targets will be realised.

In the course of the OPA's analysis it became clear that much greater long term savings were possible (7900 MW in total) than the 5000 MW target established through the Directive for 2025. The targets set out in the OPA directive represent 65% of the available potential. It is worth recognising that the conservation potential was derived from an aggressive scenario. The uncertainty associated with the available potential (determined primarily through modelling) suggests planning for 65% is the prudent course of action because of the higher degree of certainty that it will be achieved. As such, the IPSP uses the 5000 MW target to assess the necessary alternative supply resources despite the fact that the OPA – through its Conservation Bureau – will strive to exceed the target.

Over the long term, the IPSP makes allowances for increasing planned for conservation targets as knowledge and experience with conservation programs accumulates such that any evaluations of conservation versus alternative supply resources are made with as accurate as information as possible. As such, the IPSP takes the strategic decision to forgo efforts to continually refine model projections in favour concentrating efforts on "learning by doing" approach through the delivery of programs, and structuring its programs to facilitate learning.

The IPSP maps conservation potentials to the aspect of the load profile they address. For example, certain energy efficiency initiatives (e.g. equipment standards) target baseload requirements whereas demand management initiatives address peak needs (Table 4.2).

Table 4.2 Allocation of conservation initiatives to aspects of the load profile

Load Aspect	**Conservation Initiatives**	**MW Reduction**			
		2010	**2015**	**2020**	**2025**
Base	efficiency, fuel switching, customer generation, demand management	550	1392	1942	2303
Intermediate	demand management	334	448	575	603
Peak	customer generation (solar), efficiency, fuel switching, demand management	524	1210	1695	2100
Total		**1410**	**3050**	**4210**	**5000**

Source: OPA 2007 D-4-1

Allocating the targets according to the aspects of the load profile occurred largely in response to technical aspects of both the load profile and the initiative in question based on the results of the system wide analysis. Decisions on allocating the targets and initiatives to programs however are less technological in nature. Three conservation programs will be used to implement the four conservation initiatives outlined above:

Resource acquisition consisting of procured energy or demand savings achieved through incentives (i.e. subsidies or payments) for customers to reduce demand, and/or upgrade and retrofit buildings for greater efficiency. Marketing and information campaigns are important elements. This is the most expensive approach due to its requirements for continual intervention.

Capability building includes knowledge and skill development pertaining to the delivery of conservation training and education programs for electricity consumers. This includes the development of conservation service providers as well as technology that provides consumers with more complete and up to date information on prices and consumption.

Market transformation activities refer to realising significant increases in market share for energy efficient technologies, production processes and buildings. A key focus is removing barriers to the adoption of energy efficient technologies and the introduction of codes and standards.

All programs are intended to make contributions over both the short and long term however the OPA envisions that resource acquisitions will contribute substantially in the short term to 2010. Between 2008 and 2010, the resource acquisition program plans to achieve 620 MW of savings in efficiency, 390 MW of demand response (in peak demand), 150 MW of customer generation, and 70 MW of savings through fuel switching. In addition, the existing commitments poject savings of 176 MW that will contribute to the total 1350 MW target by 2010.

The short term focus on resource acquisition is based primarily on feasibility. Greater uncertainty and limited experience with the other two programs suggests that relying on either in the short term is not feasible. Over the long term, the contribution from resource acquisition is projected to decline and capability building and market transformation activities are projected to increase in importance over the long term. Codes and standards for instance are expected to deliver much of the energy efficiency targets over the long term. Capability building and market transformation programs require considerable time and resources to establish and little knowledge currently exists as to their effectiveness. The relatively high certainty that the 2010 target would be achieved was thus a key decision criterion. A decision supported by the Conservation Business Stakeholder Advisory Group of industrial, commercial and residential consumers as well as civil society, academia, and other relevant experts.

The focus on resource acquisition in the short term is designed to generate better information than is available from modelling exercises. Enhanced data quality improves the quality of planning exercises and informs new and existing program design and development.

It also enables better assessments of set targets and the likelihood of meeting or surpassing them. A “learning by doing” approach to capability building and market transformation is also employed in this regard as continual assessments are planned to evaluate experiences.

The IPSP only sets out how conservation targets are to be achieved during the 2008-2010 period according to market segments (e.g. industrial, commercial, mass market) target by resource acquisition programs. Rather than set program-based targets for the long term, the OPA suggests the development and implementation of conservation programs will be an iterative process where new programs will be introduced and certain programs discontinued as experiences are monitored and evaluated.

Due to a high level of uncertainty regarding the effectiveness of conservation programs in Ontario, the IPSP introduces a systematic approach to exploring and generating better information through its Evaluation, Monitoring and Verification (EM&V) program. The OPA has committed 5% of its Conservation program budget to the EM&V program to enhance the quality of the information used for planning purposes. The use of such information is to be used to:

1. Assess how the four conservation initiatives each contribute towards meeting the 2010 target
2. Enhance data quality used in forecasting efforts and increasing the accuracy and reliability of the data used to generate conservation potentials employed in electricity system planning
3. Evaluate the cost effectiveness of each of the three program types and thereby enhance the development of programs (new and existing). (OPA 2007 D-4-1)

The EM&V approach is systematic to the extent that it will establish a data warehouse to track the results of conservation initiatives. The OPA will also engage in a comprehensive review every three years of all measures employed to realise conservation targets including key assumptions affecting projections. Program evaluations conducted by third parties are also a key element of conservation program delivery.

IPSP efforts oriented towards the longer term target three specific areas for enhancing capability building:

1. Development and skill enhancement of a variety of program design and delivery agents;
2. Development and skill support of evaluation, measurement & verification professionals;
3. Development of the customer ability to understand and incorporate Conservation (OPA 2007 D-4-1).

These priorities reflect a specific uncertainty related to the human resource development, identified as an essential element of realising plan outcomes, as is further evident from the Government's Agency Review Panel (2007) – an advisory group tasked with providing specific advice on the issue for the electricity sector as a whole.

The IPSP also promotes greater energy efficiency requirements through codes and standards, despite the fact that it does not have the authority to establish them. Activity in this regard is to include:

> The identification of, and justification for, minimum efficiency levels and ensuring OPA's priorities are considered in changing standards. In this regard, the OPA will conduct research regarding best practices in standards development as well as fund the development of standards at the Canadian Standards Association or other appropriate bodies; and working with federal and provincial agencies and others to refine and improve data collection, evaluation and reporting of standards related work (OPA 2007 D-4-1).

In summary, the IPSP targets conservation programs that are likely to be effective in the short term, but structures their implementation to generate better information over the long term. Likewise, it establishes an explicit commitment to examine and advocate for certain issues (e.g. standards) that do not fall directly within its jurisdiction but are important to its work.

4.2.2 Renewables

The Directive instructs the OPA to achieve 15700 MW of renewable electricity capacity by 2025. This represents an increase of approximately 8000 MW of electricity generated from hydro, wind, solar, and biomass over the 2003 baseline of 7702 MW. Over 500 MW of renewable capacity have been added since 2003 with commitments in place for 1415 MW while another 6411 MW are planned for (Table 4.3).

Table 4.3 Existing, committed and planned renewable generation capacity by source (MW)

Resources	**Existing**	**Committed**	**Planned**	**Total Renewables**	**Target**
Hydro	7788	62	2921		
Wind	395	1251	3039		
Bioenergy	75	14	450		
Solar	0	88	0		
Total	**8258**	**1415**	**6411**	**16084**	**15700**

Source: OPA 2007 D-5-1

With commitments in place to meet the 2010 target, the IPSP focuses on planning to meet the 2025 target. This requires establishing a set of “feasible resources based on lowest cost or on expected responses to directives or procurement programs” (OPA 2007 D-5-1). The IPSP explores all hydro resources to the maximum feasible potential as well as all renewable resources projected to be procured through the province’s standard offer (i.e. feed-in tariff) programs, which guarantees prices paid to generators (wind, solar, hydro, bioenergy) operating below a 10 MW capacity threshold. In addition, the IPSP contains plans for large wind power sites to contribute the resources necessary to meet the renewable target.

Potential resources were first identified largely irrespective of transmission requirements or policy (i.e. land-use) constraints associated with the development of hydroelectric resources. Potential wind capacity however was excluded from sites located above the 50th parallel north latitude (far from population centres), within protected areas, at off-shore sites, and in areas buffering infrastructure. Still, the identified potential for both small and large wind power sites was well in excess of the 5000 MW constraint imposed over the course of the plan due to the operational limitations associated with integrating an intermittent resource into the transmission network.

The IPSP further identifies the transmission facilities necessary for the realising the planned increase in renewable resources. Substantial inter-regional transmission upgrades for example, are required because many of the renewable resources are located considerable distances from population centres but still within reasonable distances from the existing transmission grid. The IPSP includes the intention to develop transmission capacity to service clusters of potential sites. The development at a particular cluster site would be facilitated through a single connection to the transmission network. This is more economically efficient than connecting each site individually. Clusters of wind sites for example, contain nearly 65% (5996 MW) of the identified potential.

In selecting preferred sites, the IPSP establishes the complete costs associated with the development of potential renewable resources through calculations of Levelised Unit Electricity Costs (LUECs). LUECs are used to assess costs including project and operating costs, connection costs, transmission system upgrade costs and adjustments for transmission losses. Cost assumptions for installation ($/kW) as well operation and maintenance (¢/kWh) were applied according to capacity (MW) for both hydroelectric and wind facilities. The simplification will not reflect site-specific factors although the cost calculations assess the most cost-effective wind, hydro, and bioenergy resources respectively. In determining the renewable resources to be included in the plan, decisions to pursue particular resources in particular locations were made primarily on the basis of feasibility and cost, although the IPSP states that flexibility, reliability, environmental performance and societal acceptance were also considered to a lesser degree.

In regards to the renewable resource potentials, considerable uncertainty characterises the biomass potential (450 MW). Several alternative primary sources are available, most of which are geographically dispersed and subject to competition for their use. The bioenergy portfolio includes municipal organic waste, waste-water treatment by-products and landfill gas, as well as forest and agricultural resources. As such, the IPSP suggests that planning for a limited potential over the long term is a prudent course of action until such a time that better information becomes available. In which case all identified bioenergy potential (450 MW) is planned for over the long term primarily because no transmission infrastructure is required for its realisation. This potential is limited to that which is expected to be procured through the standard offer program for small-scale production under 10 MW.

With respect to solar resources, the IPSP plans for 88 MW of solar facilities under existing commitments through the standard offer program. It assumes any new facilities introduced over the long term will replace commitments that are not achieved. Small solar generation is included under the customer-based generation program for conservation.

Most of the renewable potential necessary to realised the Directive’s targets will be achieved through hydroelectric and wind power developments. Analyses of the unit electricity costs reveal hydroelectric developments to be superior to wind for cost purposes (Table 4.4).

Table 4.4 Levelised unit electricity cost ranges (all-inclusive) by region, hydro and wind

Region	Hydro	Wind
East	3.97 – 8.55	8.27 – 9.59
Northeast	2.45 – 8.49	8.74 – 11.01
Northwest	2.48 – 8.30	9.64 – 11.50
South	3.11 – 7.02	7.44 – 10.10

Source: OPA 2007 D-5-1

Hydroelectricity's costs advantage was the primary factor in the IPSP including the intention to develop all feasible hydropower prior to pursuing wind power. Protected areas designations and land-use agreements with indigenous peoples limit the feasible development of numerous potential sites and approximately 1756 MW of planned hydropower development are contingent upon the successful negotiations with affected indigenous groups. Should agreements not be reached the IPSP will pursue a larger proportion of wind resources and/or the expansion of transmission capacity to import hydropower from neighbouring jurisdictions.

In order to meet the renewable target as laid out in the Directive, nearly 2700 MW of wind power capacity is required by 2025. During IPSP development, the province's standard offer program (SOP) had received, and was in the midst of processing development applications for 2787 MW of renewable generation capacity. The IPSP assumes this number will be realised over the course of the IPSP based on the expectation that new applications would, at minimum, serve to replace those which are rejected. The IPSP adjust the 2787 MW figure according to transmission and distribution constraints, and further to account for those applications from projects other than wind power. With committed wind power projects under the standard offer program accounted for, the IPSP plans for 1148 MW of wind capacity from small (<10 MW) developments.

There is 1508 MW of wind capacity needed to meet the Directive target, which will be met by the development of large wind power sites procured by the OPA. The IPSP plans for the development of an additional 384 MW of wind capacity beyond the target due to the likelihood that all planned resources may not materialise. Large wind power sites for potential development are selected according to the lowest LUEC which includes transmission. In order to hedge against uncertainty, sites that would provide twice as much capacity as necessary were identified for development. The total capacity likely to be implemented however only exceeds the target by a narrow margin due in part to the OPA's assessment that exceeding the renewables target would serve to displace more cost-effective supply resources.

For planning purposes, the IPSP identifies four clusters of potential sites, which contain twice the capacity necessary to meet the target. As indicated, clusters were selected such that the appropriate analyses and actions with respect to transmission requirements could proceed, with sites selected on the basis of all-inclusive LUEC calculations. Although the IPSP pre-selects potential sites in excess of the target, it does not dictate the order, nor does it specify which sites are to be developed. Neither does it preclude the development of alternative potential sites at the initiative of private interests. Rather, the IPSP establishes the targets and context for procurement processes with the decisions to undertake development subject to factors outside the control of the OPA, such as the interests of developers and/ or those of affected communities.

One outcome of using cost effectiveness to explore opportunities was the exclusion of off-shore wind resources. Their appropriateness is under consideration, but will not be pursued until they are deemed feasible. Likewise, pumped storage has potential but despite the fact that the current IPSP does not include plans for pumped storage, it indicates future plans will assess the potential associated with storage as greater certainty with respect to load forecasts and baseload resource projections is achieved.

In setting renewable resource requirements, the IPSP evaluates the cost-effectiveness of exceeding the renewables target. The analysis compares: (i) the LUEC for the most cost-effective wind power site excluded from consideration, which would be developed to exceed the target, with (ii) the LUEC of combined cycle gas turbine generation (CCGT), which is the resources it would displace. With both generation types adjusted for capacity, their analysis reveals CCGT to be more cost effective such that exceeding the target is not cost effective. Still, the IPSP indicates the differences are relatively small, and should be subject to more extensive analysis in future plans.

In addition to the primacy of feasibility and cost considerations, flexibility was another relevant decision criterion with respect to acquiring the necessary renewable resources. Flexibility was addressed primarily by identifying twice the necessary wind power capacity that would be needed to meet the target and by leaving considerable scope for adjusting wind power development over successive IPSPs. The current IPSP plans for the development of renewables in three stages (Table 4.5).

Table 4.5 Planned development of renewable resources

Resource	**Stage 1: 2010-2015**	**Stage 2: 2016-2019**	**Stage 3: 2020 +**
Hydro	900	390	1660
Wind	1610	910	570
Bioenergy	210	200	50
Total	**2720**	**1500**	**2280**

Source: OPA 2007 D-5-1

Two aspects of the planned schedule stand out. Over half of planned wind resources are schedule for development during the early years of the plan (2010-2015) and over half of the planned for hydro resources are scheduled for development after 2020. The quality of available information is the primary reason underlying the schedule for hydro resources. Better information is required with respect to site conditions, costs, potential capacity for several sites, and scheduling development for later in the plan should allow for the assembly of the necessary information upon which to make the necessary investments.

Ultimately, the realisation of renewables target is subject to several uncertainties that the IPSP characterises as risks. Although the IPSP is concerned for instance, about the availability of wind turbines, more fundamental uncertainties are also recognised. As stated, success in procuring resources relies upon proponents capable of financing and developing the necessary resources, which in some cases may need to occur within relatively short time frames. Likewise, potentially lengthy regulatory approval processes for new projects and their associated transmission upgrades may also threaten the ability of new renewable resources to be delivered on time. In addition, engagement with local communities (Indigenous or otherwise) is also required to resolve potential land use conflicts over sites for hydro and wind power development. The inherent uncertainty associated with technological evolution also poses a challenge for planners.

On a technical level, the approach to managing uncertainty consists primarily of planning for significant excess wind power capacity, and scheduling substantial renewables development for completion prior to 2021. Again, the process of successively developing IPSPs suggests that targets and plans will be subject to continual review as new resources are introduced over the course of the planning period, and associated experience is gained. In summary, the OPA plans to “monitor, on a continuing basis, developments on specific projects, as described previously, and general developments in renewable resource technologies and costs.... [and] barriers to renewable resource development.... [addressing] barriers within its the scope of responsibility, and will bring other barriers to the attention of those having the means to address them" (OPA 2007 D-5-1).

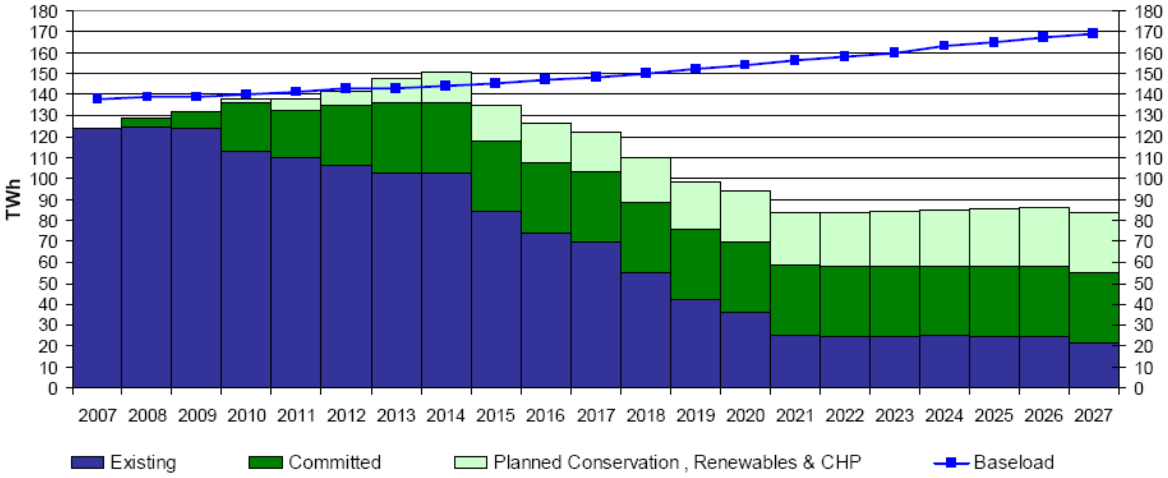
4.2.3 Conventional Resources

The Directive requires the development of nuclear capacity to meet baseload electricity requirements subject to a 14000 MW limit on installed in-service capacity. In addition it also requires the maintenance of natural gas capacity for use during peak times and in pursuit of "applications that allow high efficiency and high value use of the fuel" (Duncan 2006). Planning for nuclear baseload capacity focuses on Ontario's electricity needs exclusive of "potential market demand involving interconnected jurisdictions" (OPA D-6-1).

The requirements for baseload capacity were determined to be approximately equal to the demand that exists greater than 72% of the time. With contributions from existing and committed baseload resources accounted for, in addition to contributions from conservation and renewables assessed against the projected load profile, the necessary baseload resources required for addition equalled approximately 85 TWh in 2027 (Figure 4.1).

As Figure 4.1 makes clear, much of the existing baseload nuclear capacity will reach the end of its life over the course of the plan. With conservation and renewable resources maximised and the option for using coal-fired resources eliminated, the IPSP considers two options for meeting the remaining baseload requirements: nuclear, and combine cycle gas turbine generation. In understanding how IPSP arrived at these two options for baseload capacity it is necessary to return to the Supply Mix Advice Report which informed the Directive.

Figure 4.1 Baseload resource capacity requirements (TWh)



Source: OPA 2007 D-6-1

The initial Supply Mix Advice Report examined four sources for meeting baseload capacity requirements: nuclear, natural gas, hydro imports from neighbouring jurisdictions, and gasification. Gasification refers explicitly to the conversion of a solid fuel source such as municipal waste, coal into a gas which is then fed into a combined cycle generation unit, as is done similarly with natural gas. Gasification has the advantage of generating lower emissions than would otherwise be the case with direct combustion of the solid fuel sources. At the time of planning, interconnections with neighbouring jurisdictions amount to approximately 4000 MW of capacity (OPA 2005), although an additional 1250 MW of interconnection capacity is in presently in development. Decisions regarding contributions from conventional sources of generation capacity were initially based on broad analyses of two factors: cost and environmental impact.

In assessing the environmental considerations, life cycle assessment was employed for each of the potential generation options. Activities pertaining to resource extraction and processing, transport, construction and operation, end-of-life decommissioning as well as non-standard operating procedures and accidents were assessed. Seven environmental aspects were included in the analysis, each weighted for the sake of comparison across impacts (Table

4.6). Weighting factors for each generation option were derived from methodologies developed for a series of extensive analyses of the externalities associated with electrical power generation produced by the European Commission.[10]

Table 4.6 Environmental aspects considered in the Life-Cycle Assessment of generation options and associated weighting factors

Environmental Aspect	Weighting factor
Greenhouse gases	20
Contaminant emissions	10
Radioactivity	1
Land use	1
Water impacts	1
Waste impacts	1
Resource availability	1

Source: OPA 2005

The results of the life cycle analysis of environmental impact revealed relatively clear results (Figure 4.2). Fossil fuel consuming technologies – partly due to the weighting factors employed – pose the greatest environmental harm. Conversely, renewable resources, particularly run-of-the river hydro, have low environmental impacts.

Cost comparisons were assessed based on the use of levelised unit of electricity cost (LUEC) calculations. LUEC is expressed in terms of dollars / MWh and measures only direct supply costs. Social costs and external benefits such as job creation and spin-off economic benefits are not included. The cost figure produced represents the total price that must be received over the entire life of the project in order to recover all costs associated with construction, operation, decommissioning, and capital. The various costs and the time at which they occur are discounted back to the present time to achieve a Net Present Value for each generating option. A 5% discount rate was employed, as were other discount rates for the purpose of comparison (Figure 4.3).

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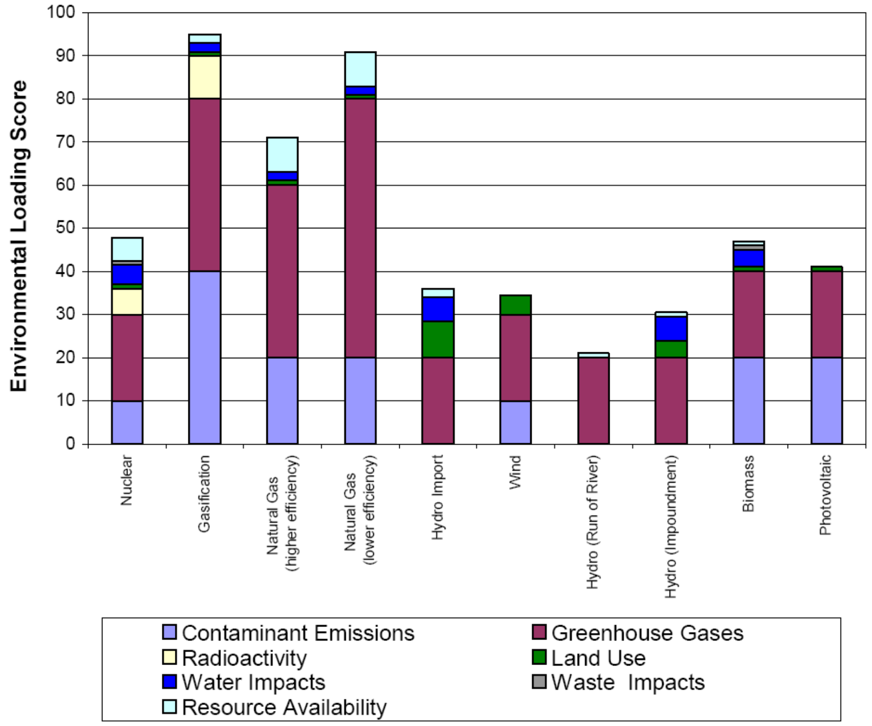
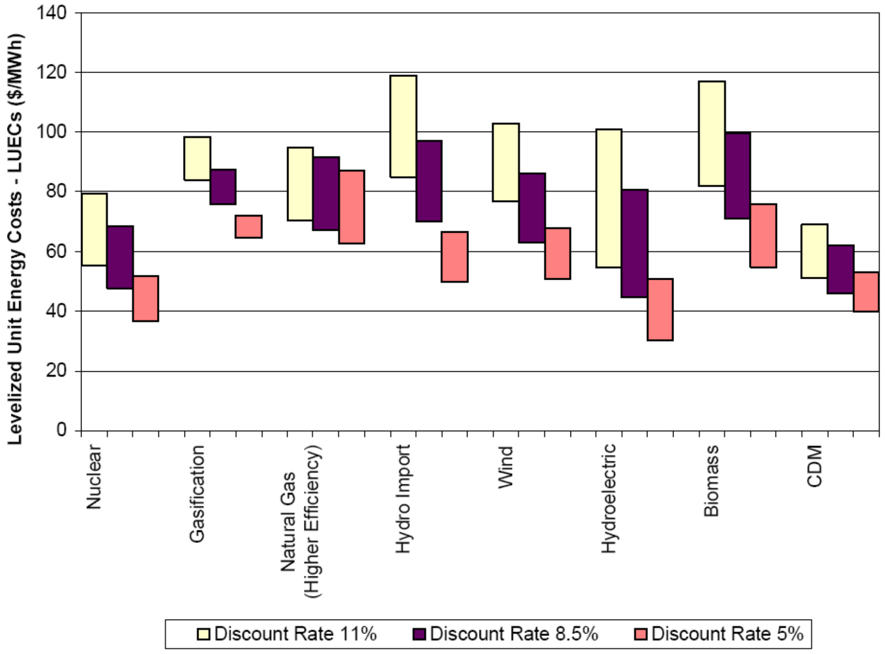
[10] Externalities of Energy – ExternE, URL: http://externe.jrc.es/reports.html

Figure 4.2 Environmental loading of electricity generation options as determined by LCA



Source: OPA 2005

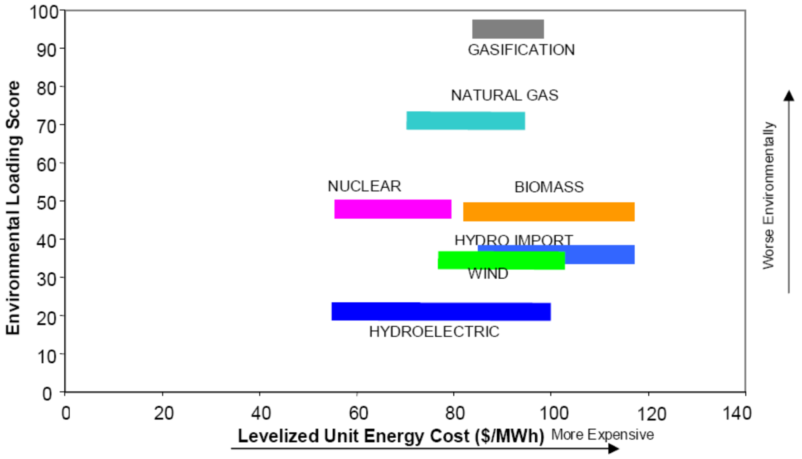
Figure 4.3 Levelised unit electricity costs for various supply options



Source: OPA 2005

Combining analyses results in a picture of generation options with varying degrees of cost and environmental benefits (Figure 4.4).

Figure 4.4 Environmental and cost factors for baseload generation



Source: OPA 2005

Further to the analyses performed in the Supply Mix Advice Report, the IPSP conducted an up to date LUEC analysis which revealed nuclear to be a more cost-effective option both in terms of new build and refurbished nuclear generation capacity. The comparison included an assessment of the risks of project delays and cost overruns through incorporating risk probabilities into the analysis.

In assessing the feasible contribution from nuclear generation, and planning for its contribution, the IPSP assumes a 10 year lead time for new nuclear capacity construction. As such, regulatory approvals processes associated with constructing new nuclear facilities have been initiated but remain in their infancy. The IPSP also suggests that the potential for alternative resources (e.g. conservation) contributing – beyond what is currently feasible and cost-effective – towards baseload requirements in the future is not precluded, and will be assessed in future plans.

The IPSP contains the intention to develop more than 10000 MW of nuclear capacity through the refurbishment of existing capacity and new build. In conducting its analysis the IPSP examined two scenarios which varied according to whether or not refurbishment occurs for the approximately 2000 MW of nuclear capacity at the Pickering B site, for which a decision by the operator is expected during 2008. The decision to refurbish does not rest with the OPA, and the OPA must therefore plan for both possibilities. In both cases, the IPSP includes the expectation that substantial capacity will be provided through the refurbishment of other existing nuclear facilities with an additional 7000 MW of nuclear capacity available for refurbishment at two other sites. As such, the amount of nuclear capacity which will be newly constructed will be either 1400 MW or 3400 MW depending on whether refurbishment proceeds at the Pickering B site.

Similar to the development of renewable capacity, nuclear capacity development (refurbishment or new build) is subject to uncertainties. The adequacy and availability of resources (financial, material, human) is a key determinant, as is the ability of proponents and the regulators to successfully complete the regulatory approvals process in a timely fashion. In addition, the IPSP assumes that new nuclear will continue to be viable and cost-effective over the life of the plan.

Regardless of whether refurbishment occurs, the IPSP projects baseload requirements will not be completely met between 2015 and 2021, due in part to the assumed 10 year lead time for new nuclear capacity. The IPSP states that meeting this shortfall “cannot be determined in detail at this time” but identifies several potential options (OPA 2007 D-6-1):

- Additional contributions from conservation, renewables, and combined heat and power where feasible
- Increased production from other feasible baseload or intermediate resources such integrated gasification combined cycle generation with carbon sequestration, or combined cycle gas turbine generation
- Purchasing interconnections

- Operation of new nuclear units within less than 10 years

Flexibility in developing nuclear baseload capacity exists in the IPSP provision to accept additional “conservation, renewable, and CHP resources to meet baseload requirements should these be feasible [and] new build nuclear baseload resources [established] earlier than assumed” (OPA 2007 D-6-1). Regular monitoring and consultation activities are a key component of OPA activities in this respect, and the IPSP contains provisions for periodic assessment of all resources.

In addition to nuclear for baseload the IPSP must also “maintain the ability to use natural gas capacity at peak times and pursue applications that allow high efficiency and high value use of the fuel” as required by the Directive. The characteristics of natural gas fired capacity are a key to its usage in the IPSP as an intermediate and peak resource. Comparatively short lead times for construction and relatively simpler siting issues are key advantages that enhance flexibility, especially when the widespread availability of turbines and natural gas are considered. The ability to locate natural gas generation facilities close to consumption for instance can improve local reliability while simultaneously alleviating the need to upgrade the transmission network. Natural gas capacity is capable of responding to uncertainties pertaining to growth in demand as well as variations in timing for the development of alternative resources. Its application is the primary source of flexibility for the IPSP particularly with respect to replacing the intermediate and peak capacity currently provided by the coal-fired capacity scheduled for phase out.

Although natural gas has many advantages, the relatively higher cost – both in terms of price volatility and high fuel costs – were the primary factor precluding its use as a baseload resource. Greenhouse gas and other air pollutants were also factors limiting its more widespread use. The IPSP considers three possibilities for natural gas capacity to meet intermediate and peaking needs over the medium to long term:

1. Building new capacity close to its final point of consumption through simple cycle[11], combined cycle[12], combined heat and power[13], and fuel cells[14];
2. Maintenance and/ or extension of existing facilities; and,
3. Conversion of coal-fired capacity to natural gas.

The Directive contains different requirements necessitating different approaches for their resolution. In meeting peak needs, the ability to respond quickly to demand fluctuations by quickly altering production is perhaps the most important factor and a chief advantage of natural gas capacity. Although some existing facilities are suited to meeting peak resource needs the IPSP indicates new capacity will need to be constructed.

With respect to new build capacity, two basic options for meeting peak demand from natural gas fired generation are possible: simple-cycle gas turbines (SCGT), and combined cycle gas turbines (CCGT). With respect to peak needs, SCGT generation is characterised by comparatively low capital costs, but higher operating costs due to greater fuel consumption per kWh produced (i.e. less efficient). Because peak usage occurs by definition for only a limited period (14% of all kWh as defined in the IPSP), new build SCGT generation is better suited to meeting peak needs. CCGT generation is better suited to higher efficiency applications as intermediate resources. Likewise, the IPSP considers combined heat and power to be a high efficiency application although its usage is best suited to meeting baseload requirements as a result of economic and operational considerations. Although fuel cells hold considerable potential for usage in high efficiency applications, their usage is excluded from the IPSP on the reasons of their present commercially infeasibility.

A key outcome of the IPSP is the allocation of natural gas fired capacity among the various technologies needed to meet the requirements. The first step taken by the IPSP is to continue the operation of one existing facility, the Lennox Generating Station (2100 MW). The IPSP also plans to acquire 586 MW of combined heat and power (in addition to commitments for 414 MW made outside the IPSP). Limited opportunities for the economic use of heat, and considerable uncertainty are the primary reasons underlying CHPs limited contribution.

The IPSP indicates that an additional 3319 or 4393 MW of natural gas capacity will be added through either SCGT or CCGT. The two figures are not a range but rather alternatives that will depend upon the decision to refurbish nuclear generation units located at Pickering B. No decisions are taken, nor are short term actions required regarding which technology will be developed following 2015 other than to suggest an additional 1119 or 2193 MW of either SCGT or CCGT will likely be required. Prior to this however, SCGT generation is predominant, contributing 1350 of planned 2100 MW by 2015, due largely to system requirements for peak resource needs. The 850 MW of CCGT will occur in one region[15] where load growth is projected to be particularly large.

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[11] Simple cycle gas turbines combust natural gas to drive a turbine generator

[12] Combined cycle gas turbines combust natural gas to drive a turbine generator (one cycle) with the heat produced then used to produce steam which drives a second turbine (second cycle)

[13] Combined heat and power applications produce electricity from the combustion of natural gas to drive a turbine generator, heat produced in the process is then used for thermal non-electricity producing applications

[13] Fuel cells produce electricity through the chemical transformation of natural gas

[15] Southwest Greater Toronto

4.3 Portfolio Development and Integration

Forecasting load is fundamental to planning the resource requirements necessary to meet demand over the short-, medium-, and long term. The load forecast establishes the projected demand for electricity over the course of the IPSP. Electricity loads vary over both daily and seasonal time frames in addition to scales of several years. Variability in demand over the long term results from uncertainty with respect to (i) economic and demographic activity, (ii) energy prices (not costs), as well as (ii) the efficiency and costs of technology in the future, including the speed at which more efficient technologies are introduced. (OPA 2007 D-1-1). Economic and demographic growth are both key influences on demand for energy services. Specifically, physical production from industry, commercial floor space, and household numbers were used to assess industrial, commercial, and household demand respectively, according to the general assumption that growth would occur in all cases. Energy price assumptions were based on a scenario that "represents a world in which technology advances rapidly and Canadians take broad actions with respect to the environment and the accompanying preference for environmentally friendly products and cleaner-burning fuels" (OPA 2007 D-1-1). That is, the analysis assumes the real prices paid by consumers will increase in the short term to 2010 prior to beginning a slow and steady decline. Assumptions with respect to efficiency improvements were somewhat less optimistic, based primarily on commercially available technologies at the present time, or those whose availability could reasonably be expected.

The Reference Load Forecast produced for the IPSP projects an average annual growth rate of 1.1% for total energy demand (157 to 195TWh) and 1.2% for peak demand (26,282 to 33,677MW) over the course of the planning period (OPA D-1-1 2007). The OPA indicates the first 10 years of the plan are more likely accurate and are therefore crucial (OPA

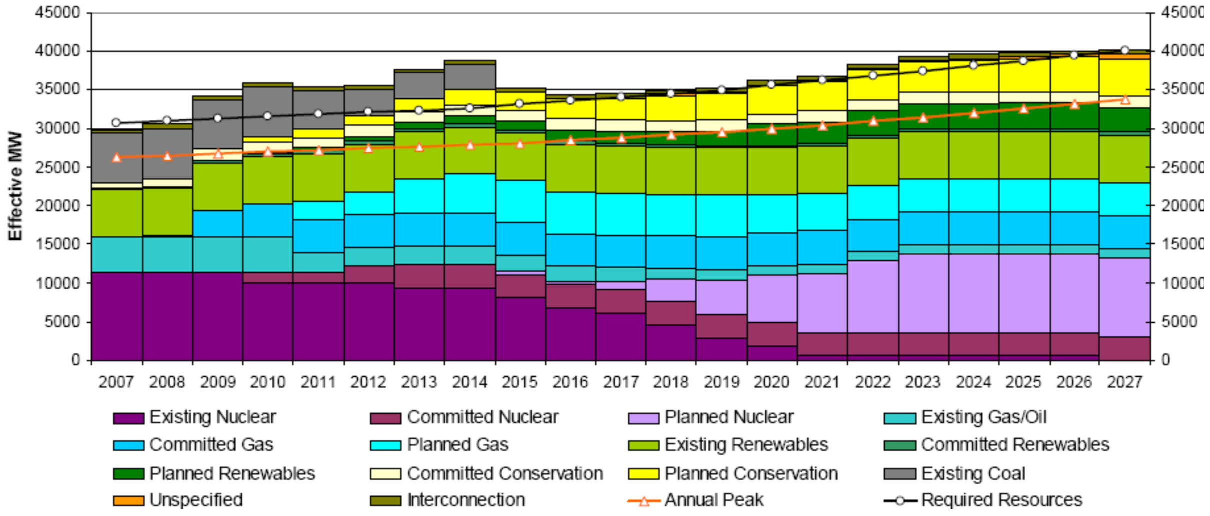
2007 C-6-1). As indicated Ontario's baseload capacity requirements were defined as the demand level existing 72% of the time whereas peak demand occurs 14% of the time, and intermediate demand the remainder (OPA 2007 D-3-1-1). For instance, the load projection forecasts baseload energy demand will increase from 138 TWh in 2007 to 169 TWh in 2027, such that baseload capacity requirements will also have to increase from 16000 MW to 19800 MW. Intermediate requirements are similarly forecast to increase from 17 TWh to 24 TWh between 2007 and 2027, with corresponding capacity increases from 4600 to 6500 MW. Peaking needs will increase from 1.6 to 1.9 TWh necessitating capacity increases from 5500 to 7300 MW.

In integrating the various elements, the IPSP maintains the no single case or scenario should be construed as the plan. Instead, the IPSP "represents the ongoing capability to meet resources requirements across a range of conditions.... [and] identify specific priorities for the near-term... develop options for the mid-term and explore opportunities for the longer term" (OPA 2007 D-9-1). Developing the resource requirements necessary to meet the Reference Load Forecast constitutes the IPSP, which the OPA characterises as a "reference plan" under the reference conditions, which are likely to change over time in one or more respects (OPA 2007 D-9-1).

The reference plan contains two possible scenarios which differ on the basis of whether 2000 MW of nuclear capacity are refurbished during the life of the plan. The IPSP indicates that approximately 32000 MW of effective resource capacity will needed to be added under the scenario where nuclear capacity refurbishment proceeds. Existing commitments total 9100 MW, leaving the IPSP to plan for an additional 23000 MW. Integration of the various planned resources is achieved by means of adding the respective combinations of resources together. Therefore, nuclear generation will account for 39% of the total installed capacity, conservation and renewables 42% with the remaining 19% provided by natural gas and other resources in 2027. If committed and planned resources are acquired as described in the IPSP, conservation and renewable initiatives will provide 38% of all additions, nuclear 36%, with natural gas and others providing 25%.

From a system perspective, Ontario’s electricity demand would by 2027 be met by 16000 MW of installed renewable resources (10700 MW hydro, 4700 MW wind, 500MW bioenergy), 6200 MW of conservation, 13300 MW of nuclear, and 10200 MW of natural gas. In effective capacity terms, one-third (33%, 13289 MW) of projected demand for electricity in 2027 will be met by nuclear, one-quarter (24%) by renewables (9792 MW) and natural gas (9682) respectively, and 15% (6218 MW) by conservation initiatives (Figure 4.5). The IPSP includes a provision for 500 MW of imports and 650 MW of unspecified resources in 2027.

Figure 4.5 Electricity supply resource mix with Pickering B refurbishment, 2007-2027



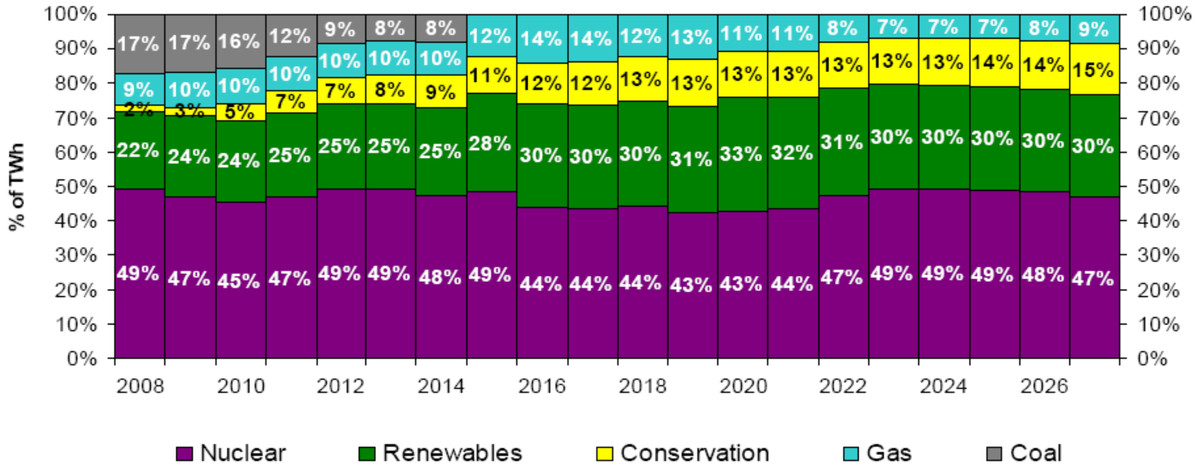
Source: OPA 2007 D-9-1

As Figure 4.5 indicates, the majority of planned resources are set to be acquired beyond 2010. Natural gas acquisitions are planned to occur prior to 2016, whereas nuclear capacity additions (either replacement or new build) will occur over the long term between 2017 and 2023. Conversely, both conservation and renewable acquisitions are projected to occur at a relatively consistent pace over the course of the plan, with over half (61%) of planned conservation acquisitions acquired by 2015.

The alternative scenario in which nuclear refurbishment does not occur, differs only slightly from the scenario described above. The addition of new nuclear capacity is planned for over the long term to replace the capacity that is not refurbished. The IPSP indicates that short term requirements could largely be met through existing resources with a variety of alternatives further capable of bridging the gap to the completion of nuclear capacity in the long term. With conservation and renewables targets unchanged in this scenario, the IPSP indicates the pursuit of natural gas resources, imports, or extensions to other existing nuclear facilities are all possible alternatives that would be considered in subsequent planning efforts should the need arise. Still, the electricity production in 2027 is expected to be similar in both cases over the long term (Figure 4.6). It is worth noting that the absence of nuclear refurbishment results in greater needs for natural gas-fired resources as well as unspecified resources (likely imports) in the mid-term but enables greater flexibility in meeting resource requirements.

In addition to the alternative scenarios described above, the IPSP further explored three alternative scenarios: higher demand growth; higher conservation (i.e. lower demand growth); and, the failure to develop northern renewables located significant distances from population centres (OPA 2007 G-1-1). As is the case earlier, each scenario contained two cases assessing whether or not the nuclear units at the Pickering B site are refurbished.

Figure 4.6 Projected electricity production by resource type, % of total TWh, 2007-2027



Source: OPA 2007 D-9-1

To the extent that demand growth is greater than expected, the IPSP contains sufficient flexibility to increase the various resources accordingly. Part of this flexibility is maintained in the short term through the maintenance of coal-fired capacity through 2014, increasing gas fired generation during the period 2015 to 2021, but also through imports from neighbouring jurisdictions over all time scales.

If demand is lower than projected, the IPSP response in the short to mid-term is to reduce the amount of gas-fired capacity and phase out coal-fired capacity prior to 2014. In the long term, there is sufficient lead time to reconsider the amount of nuclear capacity required in the next IPSP as well as alter the volume of resources imported from neighbouring jurisdictions.

In the event that the necessary transmission requirements fail to materialise, this would preclude the development of 2000 MW of hydroelectric capacity, and 500 MW of wind, which in effective terms equals approximately 1600 MW. In response, the IPSP suggests that additional wind capacity exists elsewhere to meet the gap, even though such an increase may test the feasibility and cost-effectiveness of the renewable resources component of the plan.

In short, Ontario's electricity strategy is to plan continuously, producing an updated plan every three years. The IPSP also employs the limited use of unspecified resources to identify requirements necessary over the mid to long term but without identifying which resource (either conservation or generation) will be implemented. On a general level, the primary means for addressing uncertainty is through periodic revision.

In more concrete terms, the IPSP faces short term uncertainty primarily in relation to the "implementation of currently planned resources". With little scope to manoeuvre in the short term, the IPSP maintains coal-fired generation and imported supplies from neighbouring jurisdictions for the purpose of ensuring reliability. Over the mid-term, considerable uncertainty exists through the introduction of conservation and renewable resources on a scale hitherto unfamiliar in Ontario. As such, the feasibility of such resource acquisitions in the combinations prescribed is unknown. In which case, the IPSP has pursued a strategy to develop and maintain a broad portfolio of options.

In the long term, precise forecasting with respect to how the demand profile will unfold is simply not possible. Uncertainty persists regarding the nature of economic growth and structural change, energy price development, and technological progress. Moreover, the potential exists for substantive change in the policy context. The IPSP does not aim to conclusively and systematically address such uncertainties, opting instead to for a monitoring approach oriented towards the production of an updated plan every three years.

5. Discussion and Analysis

Long term planning is the central element influencing virtually all aspects of the electricity regime. It is the primary vehicle for electricity policy implementation, directing the development of supply and demand management resources towards the achievement of policy ends, influencing development of the transmission network, and ultimately the social costs of the electricity system. As above, this section will employ a modified version of Jaccard and Mao's (2002) IRP framework for structuring the analysis. Whereas the previous section was primarily descriptive, this section is analytical in scope. It will focus on the actions taken to meet the forecast demand over time, inclusive of the planning priorities and objectives which guide action. The following sections will therefore assess the IPSP's (1) scope and objectives; (2) supply and demand resource options; and, (3) alternative portfolios and the corresponding analyses conducted in creating the desired portfolio.

In assessing the IPSP, this analysis will seek to illuminate the strategic approach employed in pursuit of *efficiency*, *reliability*, and *environmental performance* as the primary elements of sustainable electricity systems. Again, the analysis will not aim to define conclusively, whether the Ontario electricity regime is, or is not sustainable. Rather, it will focus on the means employed in pursuit of the above elements, and how the IPSP integrates and balances these elements in pursuit of sustainability. In this regard, the analysis will further explore a cross-cutting theme, examining how the IPSP engages in the active pursuit of solutions.

Ontario's electricity regime is characterised by substantial government intervention. This constrains the use of market-based instruments for the purpose of addressing externalities. Ontario's electricity regime addresses externalities through regulation and planning, with the decision to plan for the phase out of all coal-fired generation perhaps the best example. Still, the ability of the IPSP to actively promote innovative solutions remains an open question. As is its ability to address negative externalities, thereby placing alternative supply and demand side resources on the equal footing needed to effectively integrate and balance the various elements and options.

In looking towards the long term, planning efforts must be careful so as to not entrench the existing advantages currently enjoyed by components or aspects of conventional systems. Action taken in the short term should not preclude future options. Moreover, it must proactively pursue solutions. As such it is worth considering how the IPSP responds to uncertainty in the maintenance and pursuit of potential opportunities that may play a critical role in allowing future generations to meet their needs. Is planning capable of coordinating an effective response to the considerable challenge that energy sustainability represents? Is the IPSP exercise – as established – endowed with sufficient scope to craft an effective response that includes the active promotion of new and innovative solutions? This analysis seeks to answer such questions.

5.1 Analysis of Scope and Objectives

Integrated planning forms the core of Ontario’s strategy for developing a sustainable electricity system. Responsibility for the strategic development of the electricity regime effectively rests with the OPA, provided it adheres with broad policy direction as outlined by the provincial government. The importance of planning objectives providing guidance cannot be understated. Maximising the cost-effective contribution from conservation activities (as a first priority) and renewable resources (second priority), prior to pursuing conventional sources are planning objectives that align closely with the broadly recognised priorities for developing sustainable energy systems as outlined, for instance, by the International Energy Agency (2006). In this respect, the planning process is guided by clear priorities widely accepted as the primary elements of sustainable energy systems. The application of those priorities however, appears to have contributed to a somewhat limited integration between analyses of the various supply and demand resources. There is an apparent tendency within the IPSP to examine conservation resources, renewable supplies, and conventional sources in relative isolation with respect to considerations of sustainability. For example, with cost-effective conservation and renewable generation considered maximised, no subsequent integrated analyses of trade-offs associated with alternative resource levels was undertaken. Although the cost-effectiveness (i.e. efficiency) of exceeding the targets for conservation and renewables was assessed through comparisons with alternatives, a similar assessment between alternative resource portfolios with respect to environmental performance was never performed. We will return to the influence of policy priorities on plan outcomes in the discussion of portfolio development and integration.

Limited integration with respect to sustainability criteria is also partially reflected in the ordering of principles (feasibility, reliability, cost, flexibility, environmental performance, societal acceptance) developed to guide the integration of various plan elements towards sustainability. As the OPA (2007 C-11-1) states:

> Feasibility and reliability are invariable in their application – all resources included in the plan must be feasible at the period of introduction in the plan and must not jeopardize reliability. The remaining four criteria are applied on a context-specific basis, depending on the circumstances of each particular decision.

To be fair, feasibility and reliability should be essential minimum requirements for any electricity system. Any failure to deliver electricity where is it is needed is obviously unsustainable. Still, two important implications arise from the above statements. First, the fact that "all resources included in the plan must be feasible at the period of introduction" limits the scope for, or the ability of the plan to actively pursue innovative solutions. What is currently not feasible or cost-effective may become more so, as experience accumulates. Yet, the IPSP indicates that any participation in processes (i.e. demonstration) aimed at overcoming limitations will itself be limited to monitoring and subsequently employing technologies where and when they become cost effective and feasible.

Second, certain criteria are "applied on a context-specific basis". The economic aspect (i.e. cost component) of the sustainability criteria receives prominent treatment as a result of the cost-effectiveness criteria outlined in the Directive. Cost-effectiveness is clearly important and cost considerations surely deserve attention. Cost-effectiveness – and the means through which it is assessed – is not the issue per se; rather it is the means through which alternative criteria are assessed, considered, and integrated.

Conservation resources were assessed on the basis of the Total Resource Cost (TRC) test. The TRC is an assessment of the benefits of conservation through an assessment of the avoided costs of constructing additional supply resources and associated transmission requirements that would be necessary in the absence of conservation.[16] The avoided costs (i.e. benefits) are then compared against the costs of conservation program development and delivery, with results of the TRC test expressed as the net present value of avoided costs minus those of program implementation costs. Provided the conservation resources result in a net benefit it is considered cost effective.

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[16] Marginal costs for single cycle gas turbine generation (as the most likely candidate for replacement generation) were employed for the analysis of avoided costs

In contrast with the cost calculations above, the criteria for flexibility, environmental performance, and societal acceptance are more qualitative in their application. The OPA recognises this in their approach to developing conservation programs stating they were "applied in a more qualitative way" (OPA 2007 D-4-1). Although not explicitly stated as such, a qualitative approach was discernible with respect to the supply resources insofar as the integration of sustainability criteria was concerned. Although flexibility is an inherently qualitative criteria, it is worth noting that environmental performance indicators were determined on a quantitative basis for air emissions, land-use impacts, radioactivity, water use, solid waste, and resource availability. However, their application is limited to the observation of trends based on plan outcomes rather than an assessment of impacts associated with alternative supply portfolios reflecting potential alternative combinations. Further reflecting the prominence of cost considerations, renewable resources for instance, "were established primarily on the basis of the feasibility and cost criteria" (OPA 2007 D-5-1).

In summary, although the priorities assigned to the IPSP are broadly consistent with those described in much of the sustainable energy literature, they appear to have inadvertently contributed towards limited integration of the various elements. In addition, a focus on immediate feasibility limits the scope for exploring potentially advantageous options that are not yet considered feasible or cost-effective within the IPSP. This focus also appears to have contributed towards the apparent incongruity between the qualitative and quantitative criteria used to assess the sustainability of the IPSP. These issues colour the development of the IPSP and will be explored further in the following sections.

5.2 *Analysis of Options Identification*

As indicated the application of the priority criteria contributed to the analysis of various supply options largely in isolation from one another. This section will assess the IPSP approach to developing supply resources including conservation.

5.2.1 Conservation

In many ways the conservation program portfolio is an important strength of the IPSP. Avoiding the construction of additional supply resources (renewable or otherwise) has important environmental and economic implications. With respect to latter, the implementation of conservation measures is subject to an important decision making criterion, such that the “most cost effective Conservation resource will be developed before committing to an alternative supply resource” (OPA D-4-1 2007). Lead times required to build supply resources are a key factor affecting commitments to new resources. Acquiring the necessary approvals as well as constructing new supply infrastructure can require several years and the IPSP has sufficient flexibility to delay major resource acquisition decisions until experience has been gained with conservation initiatives implemented during the period 2008 and 2010. The strategic orientation towards acquiring experience and knowledge in this respect, and the commitment to “promote innovation and flexibility” will likely prove invaluable (OPA 2007 C-7-2). Moreover, the IPSP goes to considerable lengths to clarify the conservation targets are not considered hard caps, and subsequent IPSPs will revisit the targets and the appropriate means for meeting and/ or surpassing them.

With respect to the active pursuit of solutions, it is the conservation initiatives which are the most effective at realising this priority. This is perhaps the greatest strength of the IPSP. The IPSP seeks a balance between achieving short term targets according to what is known to be effective, with the pursuit of knowledge and experience necessary to realise long term goals. The establishment of a systematic approach – the Evaluation, Monitoring and Verification program – is fundamental in this respect. The orientation towards learning is further evident in the IPSP approach to developing its Capability Building and Market Transformation Activities and the respective priorities assigned (Table 5.1)

Table 5.1 IPSP learning-oriented activities in support of conservation

Capability Building	**Market Transformation**
Development and skill enhancement of a variety of program design and delivery agents; Development and skill support of evaluation, measurement & verification professionals; Development of the customer ability to understand and incorporate Conservation	Identification of, and justification for, minimum efficiency levels and ensuring OPA's priorities are considered in changing standards. In this regard, the OPA will conduct research regarding best practices in standards development as well as fund the development of standards at the Canadian Standards Association or other appropriate bodies Work with federal and provincial agencies and others to refine and improve data collection, evaluation and reporting of standards related work. Work to identify legal and government policy opportunities and barriers to conservation.

Source: OPA 2007 D-4-1

As indicated, considerable effort is directed towards maximising the effectiveness of conservation initiatives and programs over the long term. With respect to the current assessment of cost-effectiveness, the TRC test for the entire 20 year period indicates conservation initiatives will yield a net benefit in the range of \$5 - \$9 billion (OPA 2007 C-7-2). In which case, the entire conservation portfolio for the period to 2010 for instance, is considered cost effective when compared with the resources necessary to meet demand in the absence of conservation efforts.[17] In taking a closer look at the TRC figure and the conservation portfolio, a learning approach also exists such that the TRC was not applied judiciously to every initiative. Some initiatives such as conservation awareness were not found to be cost effective yet they were still included as they serve a purpose in fostering capability building and market transformation activities over the long term.

5.2.2 Renewables

In contrast with the approach to generating improved information in pursuit of ever greater conservation, the IPSP takes a far less proactive approach to generating information in its renewables scheme. As Table 4.3 shows, renewable capacity additions will be met through approximately equal contributions from hydro-electric and wind power with an additional 450 MW from bioenergy. Uncertainty regarding the increased application of renewables is noted in several places. In some cases this merely reflects the level of detail at which information exists for specific sites. For example:

> Site-specific data on many potential new hydroelectric sites, especially those that would come into service beyond 2015, is extremely limited, meaning that installed capacities, energies and costs have a significant degree of uncertainty. While the present analysis provides justification for pursuing the development of these sites, the next steps must focus on improving understanding of the site specifics (IPSP 2007 D-5-1).

In other cases, the analysis of renewables reflects broader uncertainties:

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[17] Supply resources used in the assessment: import of 2000 MW starting in 2015, costing $4500/kW; simple cycle natural gas capacity - 600 MW in 2015 and an additional 900 MW in 2027, costing $750/kW; two extra nuclear units of 700 MW each, coming in service in 2016 and 2017 respectively, costing $3,400/kW; advancing 500 MW of Pumped Generating Station (PGS) from 2020 to 2016 and adding another 1000 MW of PGS in 2016, each costing $1500/kW.

> the amounts of bioenergy assumed in the Plan should be viewed as illustrative or representative, not as precise forecasts
>
> Storage, for example, via pumped generation, or coordinated dispatch of hydroelectric and wind facilities, has the potential to increase the value and amount of wind resources.... The next IPSP will contain further assessment of the potential for storage resources, both alone and in combination with wind resources.
>
> Off-shore sites were not included in the... study of large wind sites on which estimates of potential resources was based. The Ontario government is currently studying the appropriateness of developing off-shore resources. Should the development of off-shore wind resources become feasible, their development will be pursued (IPSP 2007 D-5-1).

Although the planning process highlights and recognises shortcomings of the available information, the pursuit of the necessary information is not coordinated in a systematic manner corresponding to the activities pursued, as is the case with those applied in pursuit of conservation. Rather, the pursuit of further information and knowledge occurs externally to the IPSP process. As such, the OPA is reliant on external agencies or organisations to acquire better information which – once acquired – may be assessed and incorporated into future planning efforts. This threatens the ability of the IPSP to actively pursue and incorporate innovative solutions. Moreover, analyses in support of future long term (i.e. beyond 2020) renewable requirements suffer from a relatively narrow scope. The future analyses identified consist of:

> Available hydroelectric data is not of a quality appropriate for a final decision on such major investments. There is a need for better quality estimates of the site conditions and impacts, construction costs and potential capacity and energy production, especially for the sites located in the Moose River Basin and on the Albany River.

> More complete cost and economic analysis than the LUEC screening analysis is required. LUEC gives a reasonable indication of cost per unit of energy, but not of value of other attributes and services, or of the timing of production. For example, it does not properly account for the fact that hydroelectric production peaks during the freshet in the spring, when system demand is at a low level and the marginal system energy costs are low.
>
> Further analysis is needed on ways of utilizing resources in tandem, such as adapting intra-day hydroelectric storage capability to match the intra-day variations in wind production. Such operation could maximize production value and avoid or delay transmission upgrades, and generally co-optimize transmission and generation resources. Gas-fired peaking capacity is an additional resource that could be brought into the analysis.

Again, there is no systematic program for addressing uncertainty comparable with that utilised to realise conservation benefits. One can assume however that, due to the identification, further information will be pursued as the necessary resources are developed. Still, was the plan to maximise contributions from all potential renewable sources (as is the case with conservation) it would likely stand to benefit from a more systematic (and integrated) exploration of, for instance better information on off-shore wind capacity, the potential to exceed the 5000 MW system operability constraint for hydro capacity, and/ or the uncertainties which surround the potentials for bioenergy and solar resources. The ability to integrate higher levels of intermittent resources is likely to improve in twenty years time, and subsequent IPSP will in all likelihood account for this. Still, the absence of any systematic pursuit of expanding wind capacity beyond the 5000 MW constraint for instance is particular striking due to the intention to employ wind power resources as a contingency resource for realising the necessary renewable resources target, in the event that the necessary transmission requirements needed to acquire northern renewable resources fail to materialise. Moreover, the IPSP includes plans to advocate for efficiency standards yet there does not appear to be a similar advocacy function in support of renewables where for instance, the OPA could advocate for the promotion of investment tax credits favouring investments in renewables or wind power research priorities such as those identified by the International Energy Agency (Table 5.2).

Table 5.2 Research priorities for wind energy

Reducing cost	**Increasing value and reducing uncertainties**	**Enabling large-scale use**	**Minimising environmental impacts**
Improved site assessment and identifying new locations, especially offshore. Better models for aerodynamics and aeroelasticity. New intelligent structures/materials and recycling. More efficient generators and converters.	Forecasting power performance. Engineering integrity, improvement of standards. Storage techniques.	Electric load flow control and adaptive loads. Better power quality.	Finding suitable locations in terms of wind potential. Compatible use of land and aesthetic integration. Noise studies. Careful consideration of interaction between wind turbines and wildlife.

Source: IEA 2006

With respect to biomass and solar resource, their acquisition is limited to that achieved through the standard offer program and its associated 10 MW constraint on project size. Better information through, for instance, a larger procurement call beyond 10 MW for either of these resources would seem at minimum appropriate for fostering better information in pursuit of greater cost effectiveness. It may be the case that the pursuit of such information is beyond the scope of the IPSP exercise; however, it would not serve to account for the apparent incongruity in approaches between conservation and renewable initiatives.

In fairness, the renewables target represents a substantial and significant increase in renewable resources. The scale of the increase should not be understated, which if realised would add approximately 8000 MW of installed capacity, more than doubling current installed capacity. By 2027, this would contribute approximately 30% of all TWh supplied with contributions from conservation counted as supply resources (Figure 4.6). The capital investments necessary to realise such a contribution is estimated at $15.37 billion (2007$) over the twenty years of the plan. Moreover, in meeting this requirement the scale of the infrastructure challenge was emphasised by government not only in relation to acquiring the necessary private capital but also in respect of the ability to acquire the necessary regulatory approvals in a timely fashion, which for all intents and purposes, will be required on a scale never before experienced in the province.

As noted, decisions to pursue particular resources in particular locations were made primarily on the basis of feasibility and cost. As such, the total renewable capacity likely to be implemented only exceeds the target by a narrow margin. The OPA analysis determined that if the target is exceeded, it would displace more cost-effective supply resources. This was determined via a comparison of all-inclusive LUECs of wind with combine cycle gas turbine generation. Again, the means through which cost effectiveness was assessed is clearly important as the LUEC calculation does not include externalities. Therefore the means through which externalities were assessed is important and we will return to the issues associated with assessing the sustainability of alternative supply resources in the following sections.

Although the costs may be expected to change over time, no alternative exists for assessing cost-effectiveness other than the information which currently exists. In this respect, the continuous production and re-production of IPSPs on a three-year cycle ensures the issues associated with cost-effectiveness – at least with respect to exceeding the target – will be re-visited. Still, the cost-effectiveness of renewables at the present point in time is not at issue, so much as the strategic approach to realising every greater contributions from such resources. The approach to identifying potential sites for wind and hydro power development, and thereby facilitating the development of renewable resources provides a valuable and important investment in information. However the approach is incomplete, or at least insufficiently coordinated with strategies for developing renewable technologies beyond what is currently considered cost-effective and/ or feasible. Part of the reason for this appears to be the consideration of renewable capacity as particularly an infrastructure challenge; an approach that neglects other important aspects. Conservation is inherently more nebulous in nature however the scale of the sustainability challenge necessitates a more proactive approach to addressing uncertainty; one at least commensurate with the approach to conservation.

5.2.3 Conventional Resources

Timing is perhaps the key issue with respect to the development of conventional resources needed to ensure a secure, reliable and sustainable electricity supply for Ontario. As indicated the IPSP assumes a ten year lead time for new build nuclear capacity. In contrast, much shorter lead-times for natural gas-fired capacity additions contribute towards its use as a replacement for existing coal-fired generation, as an intermediate and peaking resource as well as a contingency resource. As indicated, the IPSP commits to assessing potential for contributions from alternative supply resources to both baseload, intermediate and peak resources needs in future plans. In which case, lead times are important, particularly with respect to new build nuclear capacity. Although long lead times are inherent to nuclear, the IPSP only commits to new build nuclear capacity in the long term, indicating a preference for refurbishment on the basis of much shorter lead-times (based on substantial experience with refurbishment) and the ability to utilise existing infrastructure (OPA 2007 D-6-1). Still, any commitments – insofar as the current IPSP is indicative – to establish new nuclear capacity or refurbish existing capacity will not be made until improved knowledge and experience with conservation and renewable resources accumulates. Again, the pursuit of new solutions with respect to renewable resources presents a concern in this respect.

In regards to the pursuit of solutions, the IPSP's treatment of new technologies also poses a concern, particularly with respect to the shortfall in supply projected to occur between 2015 and 2021, after which point in time nuclear capacity additions are projected to meet requirements. As indicated the IPSP identifies potential options to meet this shortfall including contributions from combined heat and power (CHP) and integrated gasification combined cycle generation (IGCC) with carbon sequestration, in addition to imports from other jurisdictions. Again, the IPSP indicates such options will be assessed in future plans according to cost and feasibility, should options such as IGCC become cost-effective or feasible; however, it does not contain actions that may foster their feasibility or effectiveness. Presumably, conservation and renewable sources will be looked at as the first and second priorities but it does not explicitly establish priorities for examining potential resources needed to meet this mid-term gap. Whereas the IPSP send a strong signal to investors that new nuclear capacity will be required, it does not do the same for alternatives. Although neither the IPSP nor the OPA is in a position to "pick winners" with uncommercial technologies as such, a window of opportunity may exist for their exploration in the 2015-2021 period, beyond which the window may close.

In pursuit of flexibility and maintenance of options, the IPSP does not preselect options but rather (and in this Author's opinion correctly) leaves such decisions to subsequent IPSPs. Still, in doing so it may not be sending the necessary signals that could assist in fostering innovative technologies. Or, at minimum, it does not suggest that environmentally superior characteristics will be included in any future analysis of resource options which relates strongly to the focus on feasibility and cost-effectiveness. As noted, the Supply Mix Advice Report contains a life cycle assessment of the environmental impacts of various supply options. With respect to the IPSP, this represents a static assessment of environmental performance. Although it is possible that another Supply Mix report could be requested, that is unlikely in the near to mid-term. In which case, the IPSP indicates that such options will be considered primarily on the basis of their feasibility and cost-effectiveness exclusive of social cost considerations (i.e. negative externalities). In the case of IGCC for instance, sequestration has the potential to eliminate a substantial share of its environmental impact associated with greenhouse gas emissions (Figure 4.2), thus greatly improving its performance. Yet, it does not appear that future IPSPs will evaluate alternatives on an equal basis with respect to external costs. Imports of primarily hydro-power resources from neighbouring jurisdictions instance, are environmentally superior to nuclear generation yet, cost considerations and uncertainty with respect to their acquisition appear to preclude their inclusion from the long term analysis. This is due in part to the application of more qualitative sustainability assessment criteria and we will return to the issue of placing future resource options on an equal footing in the following section. Still, the IPSP appears to forego a potentially valuable opportunity to signal an intention to acquire environmentally superior resources, other than to suggest imports are under consideration.

5.3 Analysis of Portfolio Development and Integration

The IPSP suffers from the absence of an integrated assessment of alternative resource supply portfolios against the sustainability criteria developed for the analysis. As indicated the qualitative application of these criteria occurred primarily in assessing the respective resources. Although the cost-effectiveness of the conservation program in its entirety (as well as with respect to specific elements thereof) was assessed through the TRC test, an assessment of alternative conservation targets was not performed. Recalling that the conservation target is 65% of the available potential, the analysis would likely have benefitted from an assessment of – at minimum – the cost-effectiveness of realising 100% of the available potential. Perhaps the limited knowledge and experience with conservation initiatives would limit the utility of such an exploration; however, it appears that such information is necessary for satisfying the decision criterion to develop the "most cost effective Conservation resource... before committing to an alternative supply resource" (OPA 2007 D-4-1). As the results of the TRC test reveal ($5-9 billion net benefit), there is in all likelihood additional scope for realising additional cost-effective conservation benefits, even in the absence of sustainability considerations.

The cost-effectiveness of opportunities for exceeding the renewables target were also assessed through a comparison of LUECs between excluded wind resources and CCGT generation. As indicated, the results of that analysis revealed that exceeding the renewables target would serve to displace more cost-effective resources. Still, it is worth highlighting the fact that the negative externalities associated with various supply resources were not included in the analysis. This is a function of the tendency to apply sustainability criteria in relative isolation.

In a manner similar to the application of the TRC test for conservation targets, the quantitative environmental performance of the entire plan was assessed. For the analysis six indicators were chosen, each quantified and assessed for each of the electricity supply resources included in the IPSP in combinations prescribed (Table 5.3). Rather than examine a range of portfolios with alternative combinations of supply resources for the purpose of minimising environmental impacts, the impact assessment is an ex post assessment of the outcomes associated with resource decisions taken. Alternative scenarios are examined but only those which were used to assess plan robustness against alternative futures. For instance, environmental indicator figures are calculated on the basis of whether or not nuclear refurbishment proceeds at the Pickering B site, in conjunction with alternatives scenarios reflecting both higher and lower demand growth (compared to the Reference Scenario) as well a scenario in which the necessary transmission requirements for developing northern renewable resources fail to materialise.

Table 5.3 Environmental Indicators

Greenhouse Gas Emissions	Three primary GHGs (CO_2, CH_4 and N_2O) are quantified for electricity resources. Sulphur hexafluoride (SF_6) emissions are also considered
Air Contaminant Emissions	Four air contaminants are quantified for electricity resources (NO_X, SO_2, $PM_{2.5}$ and mercury)
Radioactivity	Public exposure to radionuclide emissions to air and water
Water Use	Water consumption and flow-through water (non-consumptive) are quantified for electricity resources in the Plan
Solid Wastes	Solid wastes are quantified and broken down according to the type and quantity
Land Use	Total physical area of land disturbance is quantified for all electricity resources. Some consideration is given to land that would remain available for other uses

Source: SENES Consultants 2007

Such an analysis provides a useful indication of how environmental indicators can be expected to change over time, and also provides a valuable baseline for monitoring future developments. Still, the utility of the analysis is limited as a result of the fact that the application of the analysis was not integrated into the decision making framework with respect to the selection of supply resources. The absence of such an integrated approach constrains the ability of the current IPSP to balance environmental externalities against cost-effectiveness. It should be recognised that there is nothing to preclude such information from being integrated into future IPSPs however, the absence of integration is a significant shortcoming of the IPSP in its current form.

The absence of the integration of environmental information is apparent in the ambivalence toward the pursuit of expanded imports of primarily hydro-electric resources from the neighbouring province of Quebec (OPA 2007 E-3-6). It appears to offer additional renewable capacity yet it is not included in the long term projections because "no procurement is assumed" for the purposes of prudence where there is no guarantee the 1250 MW can be realised on a firm (i.e. guaranteed) basis. Still, were environmental aspects integrated to the extent that costs were assessed on an equivalent basis, there is a greater likelihood that renewable resources could have been expanded to an even greater extent.

6. Conclusions

Fostering perpetual improvement towards greater efficiency and environmental performance is possibly the greatest challenge facing the development of sustainable energy systems. Energy efficiency, renewable generation, as well as other low-carbon technologies are well accepted elements of sustainable electricity systems, subject of course to the limitations of reliability. Still, the challenges associated with acquiring and integrating the information necessary to overcome existing limitations and thereby foster perpetual change in the direction of sustainability are considerable. In this regard, the strategy to engage in continuous development of integrated power system plans that prioritise conservation and renewable generation is an important strength. The strategic priorities assigned to IPSP development align broadly with the elements of sustainable electricity systems. In principle their application and the continuous development of IPSPs should serve to ensure the best available information is incorporated into future planning efforts, acting as a guard against uncertainty, opening up the possibility of a flexible and evolutionary approach. Still, the ability of IPSPs to proactively foster innovative solutions is unclear. In this respect results are somewhat mixed, which is a particular concern in light of the IPSP position as the focal point of the provincial energy transformation program.

The uneven treatment of conservation and renewable generation development is a persistent concern. The development of conservation programs and initiatives oriented towards better information and effectiveness is definitely a strong point of the IPSP. At the same time, it is not entirely clear why an equivalent approach to fostering renewable generation was not employed. Part of the answer may lie in the perception of renewable generation as primarily an infrastructure challenge, rather than approaching the expansion of renewable capacity more broadly. Whereas the IPSP undertakes conservation initiatives that serve long term benefits but may not presently be cost-effective (e.g. conservation awareness), it does not do the same for either renewable generation or other low carbon technologies that may not presently compare favourably with established technologies. Expanding the approach to developing supply infrastructure (renewable or otherwise) could be enhanced by mirroring the approach applied to conservation.

It is worth noting the pursuit of better information pertaining to renewable generation does occur; however, it does so largely outside the jurisdiction of the institutions of the existing electricity regime.[18] Part of this relates to the scope of the IPSP process, and priorities directing it. The immediate focus of the IPSP on meeting targets as directed (and defined by law) limits the ability of the OPA or the IPSP to foster innovation. Perhaps it is asking too much of the IPSP for it to maintain a secure, reliable and sustainable electricity system while simultaneously fostering innovative solutions; however, it remains the primary vehicle for implementing strategic electricity policy and, in the case of conservation the IPSP is oriented towards achieving all such objectives.

The priorities assigned have also resulted in a somewhat a limited integration and balance in pursuit of sustainable electricity system development. The primary recommendations arising from this analysis suggest further research and effort must be directed towards the achievement of further integration (a) within the IPSP, and (b) with ongoing efforts oriented towards overcoming the limitations associated with developing supply resources. The government is correct in pursuing conservation and renewables as priorities; however, the integration of negative externalities into the analysis is largely absent. Fortunately the information necessary to monitor environmental performance exists, yet it remains unclear how such information will be integrated into future decisions.

Despite its shortcomings, the IPSP represents an ambitious and significant step towards a more sustainable electricity system. The expansion of renewable capacity and the targets established compare favourably with visions and targets developed and pursued in other jurisdictions. In an extensive review of numerous scenarios examining potential contributions from renewable sources of electricity for instance, Martinot et al. (2007) found most scenarios indicate 20-35% of electricity from renewables is possible by 2020. In comparison, 33% of electricity produced in Ontario would derive from renewable sources in 2020 according to the plans as laid out in the current version of the IPSP. Moreover, many of the above studies are scenarios representing what could be achieved, rather than a specific plan which outlines a set of activities oriented to achieve high levels renewable generation.

In summary, the sustainable energy development must position itself to foster improvements in both efficiency and environmental performance. In this regards, the IPSP is guided by the appropriate priorities, yet the approach to development remains incomplete. It focuses too intensely on achieving the policy priorities in isolation, relying primarily maximising the cost-effective pursuit of conservation and renewable resources. No plan can be all things at once, yet there remains a crucial yet unfulfilled aspect pertaining to the active pursuit of solutions concerning supply resources. Approaching the development of supply resources in a manner similar to that of conservation is essential. Likewise, integrating environmental criteria into decisions that balance efficiency, reliability, and environmental performance is also a minimum requirement; one that is challenging but nonetheless essential for orienting the electricity system towards a more sustainable path, one where tradeoffs are explicit and solutions are not only actively pursued, but also realised.

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[18] Electricity related research is under the jurisdiction of the Ontario Ministry of Research and Innovation

References

Agency Review Panel (ARP). 2007. *The report of the Agency Review Panel on Phase II of its review of Ontario's provincially owned electricity agencies*. Toronto, ON, Canada: Queen's Printer for Ontario.

Alanne, K., and Saari, A. 2006. Distributed energy generation and sustainable development. *Renewable and Sustainable Energy Reviews* 10: 539-558.

Caspary, G., Evans, M., and Buxtorf, L. 2007. Stabilising energy-related greenhouse gas emissions: making "technology wedges" feasible. *Renewable Energy* 32 (5): 713-726.

Dewees, D.N. 2005. Electricity restructuring in Canada. In: *Canadian Energy Policy and the Struggle for Sustainability*, ed. G.B. Doern, 128-150. Toronto, ON, Canada: University of Toronto Press.

Doern, G.B. (2007). *Red Tape, Red Flags: Regulation for the Innovation Age*. Ottawa, ON, Canada: Conference Board of Canada.

Doern, G.B. and Gattinger, M. (2003). *Power Switch: Energy Regulatory Governance in the 21st Century*. Toronto, ON, Canada: University of Toronto Press.

Duncan, D. 2005. *Re: Commencement of long term planning exercise and request for recommendation on supply mix*. Letter from Minister of Energy to Jan Carr (CEO) and Members of the Board, Ontario Power Authority. 2 May, 2005.

________. 2006. *Re: Integrated Power System Plan*. Letter from Minister of Energy to Dr. Jan Carr (CEO), Ontario Power Authority. 13 June 2006.

Electricity Act. 1998. *Consolidated Statutes of Ontario* C.15: Schedule A.

Electricity Conservation and Supply Task Force. 2004. *Tough Choices: Addressing Ontario's Power Needs. Final Report to the Minister*. January, 2004. URL: http://www.energy.gov.on.ca/english/pdf/electricity/ TaskForceReport.pdf [accessed April 20, 2008].

Goldemberg, J., and Johansson, T.B. (eds.). 2004. *World Energy Assessment: Overview 2004 Update*. New York, NY, USA: United Nations Development Program.

Green, R. and McDaniel, T. 1998. Competition in electricity supply: will "1998" be worth it? *Fiscal Studies* 19 (3): 273-293.

Group of Eight (G8). 2005. *The Gleneagles communiqué: climate change, energy and sustainable development*. 8 July 2005. Gleneagles, United Kingdom. URL: http://www.g8.gov.uk/Files/kFile/PostG8_Gleneagles_ Communique.pdf [accessed February 15, 2008].

Hendriks, C.M., and Grin, J. 2007. Contextualizing reflexive governance: the politics of Dutch transitions to sustainability. *Journal of Environmental Policy and Planning* 9 (3-4): 333-350.

Independent Electricity Market Operator. 2002. *Market Surveillance Panel Report on the IMO-Administered Markets for the First Four Months: May – August 2002*. 7 October 2002. Toronto, ON, Canada: Independent Electricity System Operator. URL: http://www.ieso.ca/imoweb/pubs/marketSurv/ms_msp Report_2002oct07.pdf [accessed April 20, 2008].

Intergovernmental Panel on Climate Change (IPCC). 2007a. *Climate Change 2007: Impacts and Adaptation to Climate Change*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

_________. 2007b. *Climate Change 2007: Mitigation of Climate Change*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

International Energy Agency (IEA). 2006. *Energy Technology Perspectives2006: Scenarios and Strategies to 2050*. Paris, France: Organization for Economic Cooperation/ Development, International Energy Agency.

_________. 2007a. *Energy use in the new millennium: trends in IEA countries*. Paris, France: Organization for Economic Cooperation and Development/ International Energy Agency.

_________. 2007b. *World Energy Outlook 2007: China and India Insights*. Paris, France: Organization for Economic Cooperation and Development/ International Energy Agency.

International Institute for Sustainable Development (IISD). 2007. *Earth Negotiations Bulletin* Volume 12, No. 354. 17 December 2007. Geneva, Switzerland: IISD Reporting Services. URL: http://www.iisd.ca/ climate/cop13/ [accessed March 6 2008].

Jaccard, M. and Mao, Y. 2002. Making markets work better. In: *Energy for Sustainable Development: a Policy Agenda*, ed. T.B. Johansson and J. Goldemberg, 41-76. New York, NY, USA: United Nations Development Program.

Jamasb, T., and Pollitt, M. 2005. Electricity market reform in the European Union: a review of progress towards liberalisation and integration. *Energy Journal* Special Issue: 11-41.

Jefferson, M. 2006. Sustainable energy development: performance and prospects. *Renewable Energy* 31: 571-582.

Johansson, T.B., and Goldemberg, J. (eds.). (2002). *Energy for Sustainable Development: a Policy Agenda*. United Nations Development Program, New York, NY, USA.

Joskow, P.L. and Schmalensee, R. 1983. *Markets for Power: an Analysis of Electric Utility Deregulation*. Cambridge, MA, USA: MIT Press.

Kemp, R., Parto, S., and Gibson R. 2005. Governance for sustainable development: moving from theory to practice. *International journal of Sustainable Development* 8: 12-30.

Lafferty, W. 1996. The politics of sustainable development: global norms for national implementation. *Environmental Politics* 5: 185–208.

Martinot, E., Dienst, C., Weiliang, L., and Qimin, C. 2007. Renewable energy futures: targets, pathways and scenarios. *Annual Review of Environment and Resources* 32: 205-239.

Morrison, R.W. 2005. Energy policy and sustainable development. In: *Canadian Energy Policy and the Struggle for Sustainable Development*, ed. G.B. Doern, 83-104. Toronto, ON, Canada: University of Toronto Press.

Meadowcroft, J. 2007. Who is in charge here? Governance for sustainable development in a complex world. *Journal of Environmental Policy and Planning* 9 (3-4): 299-314.

Newbery, D.M. 2002. Problems of liberalizing the electricity industry. *European Economic Review* 46: 919-927.

Newbery, D.M. and Pollitt, G. 1997. The restructuring and privatization of Britain's CEGB: was it worth it? *Journal of Industrial Economics* 14 (3): 269-303.

Ontario Clean Air Alliance. 2002. URL: www.cleanair.web.ca and www.electricitychoices.ca.

Ontario Hydro. 1990. Providing the Balance of Power: Ontario Hydro's Plan to Serve Customers Electricity Needs. Ontario Hydro, Toronto, ON, Canada.

Ontario Ministry of Finance. 2006. *2006 Census highlights – factsheet 1*. URL: http://www.fin.gov.on.ca/ english/economy/demographics/census/cenhi06-1.pdf [accessed February 25, 2008]

Ontario Ministry of Energy (MoE). 2007. Results-Based Plan 2007-2008. Ontario Ministry Of Energy, Toronto, ON, Canada. URL: http://www.energy.gov.on.ca/index.cfm?fuseaction=about.plan0708 [accessed April 24, 2008].

Ontario Power Authority (OPA). 2005. Supply Mix Advice Report. December 2005. Ontario Power Authority, Toronto, ON, Canada.

Ontario Power Generation (OPG). 2001. *Greenhouse Gas Action Plan – 2000*. Report submitted to Canada's Climate Change Voluntary Challenge and Registry.

Organisation for Economic Cooperation and Development (OECD). 2001. *OECD Environmental Strategy for the First Decade of the 21st Century*. OECD, Paris, France.

________. 2002. *Governance for sustainable development: five OECD case studies*. OECD, Paris, France.

Pacala, S. and Socolow, R. 2004. Stabilization wedges: solving the climate problem for the next 50 years with current technologies. *Science* 305: 968-972.

Patterson, W., Eberhard, A., and Suaréz, E. 2002. Towards sustainable electricity policy. In: *Energy for Sustainable Development: a Policy Agenda*, ed. T.B. Johansson and J. Goldemberg, 77-114. United Nations Development Program, New York NY, USA.

Plourde, A. 2005. Changing nature of national and continental energy markets. In: *Canadian Energy Policy and the Struggle for Sustainable Development*, ed. G.B. Doern, 51-82. Toronto, ON, Canada University of Toronto Press.

Raskin, P., Banuri, T., Gallopin, G., Gutman, P., Hammond, A, Kates, R., and Swart, R. 2002. *Great transition: the promise and lure of the times ahead*. Boston, MA, USA: Stockholm Environment Institute.

Rittel, H.W. and Webber, M.M. 1973. Dilemmas in a general theory of planning. *Policy Sciences* 4 (2): 155-169.

Sathaye, J., A. Najam, C. Cocklin, T. Heller, F. Lecocq, J. Llanes-Regueiro, J. Pan, G. Petschel-Held , S. Rayner, J. Robinson, R. Schaeffer, Y. Sokona, R. Swart, H. Winkler. (2007). *Sustainable Development and Mitigation*. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Schott, S. 2005. Sustainable and socially efficient electricity production. In: *Canadian Energy Policy and the Struggle for Sustainable Development*, ed. G.B. Doern, 174-199. Toronto, ON, Canada: University of Toronto Press.

SENES Consultants. 2007. *Supplementary Environmental Impacts Report for the Integrated Power System Plan*. Richmond Hill, ON, Canada: SENES Consultants Ltd.

Smith, A., Stirling, S. and Berkhout, F. 2005. The governance of sustainable, socio-technical transitions. *Research Policy* 34: 1491-1510.

Spalding-Fecher, R., Winkler, H., Mwakasonda, S. 2005. Energy and World Summit on Sustainable Development: what next? *Energy Policy* 33: 99-112.

Stern, N. (2007). *The Economics of Climate Change: the Stern Review*. Cambridge, United Kingdom: Cambridge University Press.

Trebilcock, M., and Hrab, R. 2005. Electricity restructuring in Ontario. The Energy Journal 26(1): 123-146.

United Nations Economic Commission for Europe (UNECE). 1998. *Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters,* 25 June 1998 (Aarhus Convention). Geneva: UNECE.

United Nations. (1992). *United Nations Framework Convention on Climate Change*. 9 May 1992. New York, NY, USA: United Nations.

________. 2002. *Report of the World Summit on Sustainable Development*. Johannesburg, South Africa, 26 August – 4 September. New York, NY, USA: United Nations.

Ugo, R. (2007). The environmental potential of IT for the ubiquitous society. *IEEJ Transaction on Electronic and Electrical Engineering* 3 (1) 27-31.

Unruh, G.C. and Carillo-Hermosilla, J. 2006. Globalizing carbon lock-in. *Energy Policy* 34(10): 1185-1197.

Vera, I., and Langlois, L. 2007. Energy indicators for sustainable development. *Energy Policy* 32 (6): 875-882.

World Commission on Environment and Development (Brundtland Commission). 1987. *Our Common Future*. Oxford University Press, Oxford, United Kingdom.

World Trade Organisation (WTO). 2007. *International trade statistics*. World Trade Organisation, Geneva, Switzerland.

Glossary of Key Terms[19]

Installed capacity The highest level of megawatt (“MW”) output at which a supply resource, or set of supply resources, is designed to be maintained indefinitely without damage to the supply resource(s). It is sometimes referred to as “maximum continuous rating” (“MCR”) or “nameplate capacity”.

Renewable resources These include hydroelectricity, wind power, bioenergy (also known as biomass) and solar power generation units located in the province. For some purposes, an interconnection that is expected to deliver renewable resources into Ontario may also be included as installed capacity capable of delivering renewable resources into Ontario. Where there is a contract for a renewable resource located outside of Ontario, that resource is considered to be used in Ontario.

Bioenergy The generation of electricity from a biological source (“biomass”), including forestry biomass (harvest residues, woody plantations), agricultural biomass/biogas (crop and animal residues, dedicated crops), and municipal solid waste (landfill gas) and municipal wastewater treatment biogas (digester gas).

Available capacity The amount of installed capacity expected to be available for operation at a given point in time, or over a given period of time.

Effective capacity The level of MW output from a supply resource or set of supply resources that is counted on towards meeting the annual system peak demand. Effective capacity may be lower than installed capacity because of factors such as energy unavailability or other operational constraints.

Existing resources Those resources in service as of June 1, 2007.

Committed resources Those resources not yet in service as of June 1, 2007 but which have a signed procurement contract with the OPA.

Planned resources Those supply resources included in the Plan that are neither existing nor committed resources.

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[19] Definitions taken from IPSP document D-5-1

Appendix I: Key IPSP Documents

The IPSP

B 1 1	The IPSP
B 2 1	Procurement Process
B 3 1	Development of the IPSP

First Nations, Métis and Stakeholder Engagement

C 1 1	First Nations and Métis Communities Engagement
C 2 1	Stakeholder Engagement
C 3 1	How the OPA Responded to the Views of First Nations, and Métis Communities
C 4 1	How the OPA Responded to the Views of Stakeholders
C 5 1	Discussion Paper 1 – June 29, 2006 (Scope and Oveview)
C 6 1	Discussion Paper 2 – September 6, 2006 (Load Forecast)
C 7 1	Discussion Paper 3 – September 22, 2006 (Conservation)
C 7 2	Discussion Paper 3 revised – December 21, 2006 (Conservation)
C 8 1	Discussion Paper 4 – November 9, 2006 (Supply Resources)
C 9 1	Discussion Paper 5 – November 13, 2006 (Transmission)
C 10 1	Discussion Paper 6 – November 10, 2006 (Sustainability)
C 11 1	Discussion Paper 7 – November 15, 2006 (Integrating the Elements – A Preliminary Plan)
C 12 1	Discussion Paper 8 – January 5, 2007 (Procurement Options)

Conservation and Supply Resources

D 1 1	Load Forecast
D 2 1	Planning Reserve Requirements
D 3 1	Determining Resource Requirements: Base, Intermediate and Peaking Requirements
D 4 1	Conservation Resources
D 5 1	Renewable Resources
D 6 1	Nuclear Resources for Baseload
D 7 1	Replacing Coal-Fired Resources
D 8 1	Natural Gas-Fired Resources
D 9 1	Meeting Resource Requirements

Transmission

E 1 1	Structure of Transmission Evidence
E 2 1	Overview of Transmission Planning
E 2 2	Facilitating the Development and Use of Renewable Energy and Enabling 2010 and 2025 Renewable Targets
E 2 3	Integrating Conservation
E 2 4	Enabling Nuclear
E 2 5	Enabling Natural Gas
E 2 6	Enabling Coal Replacement

Procurement Process

F 1 1	Procurement Process Background

Plan Outcomes

G 1 1	Plan Robustness
G 2 1	Plan Cost
G 3 1	Consideration of Safety, Environmental Protection and Environmental Sustainability

Appendix II: Individuals Interviewed

Kevin Pal	Manager, Strategic Policy Branch, Ontario Ministry of Energy
Karen Frecker	Planner, Ontario Power Authority
Nancy Marconi	Planner, Ontario Power Authority