Energy Studies Review Vol. 11, No. 1, 2003 pp.100-113

Canadian Energy Up-Date

John Walsh

Formation of the Association for the Study of Peak Oil

The Association for the Study of Peak Oil (ASPO) has been formally established by a group of universities and government institutions in Europe with support from the Astor Foundation. A regularly published Newsletter may be found on the Web at www.energiekrise.de/e/news/aspo.html. A meeting of ASPO was held 23-24 May 2002 at Uppsala University in Sweden 23 –24 with speakers from a number of countries but not Canada. A summary of most of the papers presented at the Uppsala Meeting, including the complete text of an interesting review of the current situation prepared by Jean Laherrère, may be found at www.oilcrisis.com. The consensus reached at this meeting was that world oil production, fairly broadly defined, will peak `around 2010 and decline thereafter.' The press release states: `ASPO plans to update this evaluation every year as new information and insights come in, with the intention of providing governments with a reliable basis for planning their responses to this critical issue.' The new organization may be contacted through Dr. R.W. Bentley of the *Oil Depletion Analysis Centre* at 305 Great Portland Street, Suite 12, London, W1W 5DA U.K. E-Mail: odac@btconnect.com.

John Walsh is an indepedent energy advisor in Ottawa.

Update, in continuous preparation for future issues of the 'Energy Studies Review', may be found on the web at: pages.ca.inter.net/~jhwalsh/update.html John Walsh may be reached at jhwalsh@ca.inter.net

New Reports

World Energy Outlook 2002

The International Energy Agency published its biannual *World Energy Outlook* on 21 September 2002. This well-known report presents projections for the supply and demand for oil, gas, coal, renewable energy sources, nuclear power and electricity, world-wide and by region, to the year 2030. It also deals with the issues of energy security, trade, investment and climate change. New features this year include chapters entitled China Energy Outlook, Energy and Poverty, and an Alternative Scenario to deal with the impact of new policies adopted to reduce carbon dioxide emissions. The Agency expects the global economy will become more dependent on oil from the Middle East over the next three decades with the result that security issues will become more important on the energy agenda. Demand for oil is projected to increase by 1.6% per year (as compared to all energy at 1.7% per year) to reach 120 million barrels per day in 2030. Almost three-quarters of the new incremental demand will come from the transportation sector. The price for oil is expected to average $US 21 a barrel through the end of this decade which compares with the price on the New York market of just less than $US 30 in October of 2002.

Chapter 13 titled *Energy and Poverty* was prepared in advance of publication in time for presentation to the *World Summit on Sustainable Development* held in Johannesburg 28 August to 4 September 2002 and may be downloaded separately without charge. This interesting document of 46 pages (with references and extensive tables) provides new country-by-country data on electrification rates worldwide with projections to 2030. It also includes estimates of the use of traditional biomass energy sources and goes on to set out a quantitative framework for strategies for the alleviation of poverty. This chapter reveals that some 1.6 billion people – one-quarter of the world population – have no access to electricity at present. Without new policies, 1.4 billion people will still lack electricity in 2030. Some 2.4 billion people rely on traditional biomass – wood, agricultural residues and dung – for cooking and heating. This number is expected to *increase* to 2.6 billion by 2030. The IEA believes that the lack of electricity exacerbates poverty and contributes to its perpetuation, as it precludes most industrial activities and related economic growth.

Though the World Summit stressed the need for electricity to reach ordinary people, there are now proposals to build the world's largest hydroelectric project at Inga Falls on the Congo River where some 40 gigawatts could be developed. Power lines are proposed to carry the energy 3000 kilometres south to South Africa via Angola and Namibia. Another line would take energy 4000 kilometres north through the Central African Republic and Sudan to Egypt. It is possible some energy might go to Nigeria. This is the opposite of distributed generation for villages from small-scale sources.

The Agency has also released three documents in late 2002 related to the climate change issue. *Dealing with Climate Change: Policies and Measures in IEA Member Countries* is the third in a series that reviews the over 200 energy-related policies and measures planned or implemented by its 26 member countries. *Beyond Kyoto: Energy Dynamics and Climate Stabilisation* details the options available in the energy sector to reduce climate change and explores the type of international agreement needed to cope with the uncertainty inherent in this field. *CO_2 Emissions from Fuel Combustion 1971 – 2000* was prepared for the Conference of the Parties (COP 8) to the UN Framework Convention in Climate Change held in New Delhi 23 October to 1 November 2002 and covers emissions from more than 140 countries and regions by sector and fuel.

Copies of the *World Energy Outlook 2002* and other documents may be obtained directly from the International Energy Agency at Books, International Energy Agency, BP 586, 75726 Paris Codex 15, France. (Fax: 33 1 40 57 67 75; E-Mail: books@iea.org. It is also available from agencies of the IEA around the world or by paid download in .pdf format). Chapter 13 *Energy and Poverty* may be downloaded separately from the Agency's Web Site at www.iea.org also in .pdf format.

Annual Report of the IEA Greenhouse Gas R and D Programme

The Annual Report of the *IEA Greenhouse Gas R and D Programme* marks the tenth year this specialized research group of the International Energy Agency has been in operation. This international collaborative activity was established in 1991 to investigate technologies for the reduction of greenhouse emissions from the fossil fuels. Canada was one of the founding 12 members and the current international chairman is Dr. Kelly Thambimuthu of Natural Resources Canada. Other Canadian members are Dr. Malcolm Wilson of the University of Regina and Mr. William Richards of Nova Scotia Power. Some 18 countries, including the European Commission, are now members and several well-known companies in the energy field are participants including ALSTOM Power, British Petroleum, ChevronTexaco, EniTecnologie SpA, Electric Power Research Institute, ExxonMobil, RWE, Shell, and TotalFinaElf.

Phase 4 of the project began in 2001 with two main objectives: improving the attractiveness of technologies for the abatement of greenhouse gas emissions; and building an understanding of the potential of these technologies among key constituents. These objectives are addressed under four broad themes: evaluating technology options; improving key mitigation technologies; implementation of mitigation technologies; and improving the understanding of mitigation technologies.

Projects where Canada plays a leading role include: geological storage in oil reservoirs where carbon dioxide is sequestered while at the same time enhancing the production of oil at the Weyburn field in Saskatchewan; geological storage in unminable coal seams in Alberta where carbon dioxide is sequestered in coal measures not expected to be mined with the concurrent enhanced release of methane; capture of carbon dioxide from flue gases including the operation of an International Test Centre located at the Boundary Dam Power Station of Saskatchewan Power; and combustion of coal in oxygen with the object of lowering the subsequent separation costs of the product carbon dioxide which requires its re-circulation to reduce excessive flame temperatures.

A special *10th Anniversary Report* was also published which summarized the main achievements and includes a brief summary of the findings from almost 90 separate technical studies undertaken over the decade. A CD-ROM was produced to accompany this report that contains overviews of each of these technical studies.

The May 2002 issue of *Greenhouse Issues* (Number 60) announced the availability of the revised version of *Ocean Storage of Carbon Dioxide*, originally published in February 1999. Of the three main natural carbon reservoirs, the ocean reservoir is by far the largest, being many times larger than the terrestrial reservoir, which in turn has a greater capacity than the atmospheric reservoir. This large capacity could be used in two possible ways: (1) by capturing carbon dioxide from large industrial point sources for injection into the deep ocean, and by (2) fertilizing the ocean with additional nutrients to increase the natural draw-down of this greenhouse gas from the atmosphere. This report of 28 pages deals mainly with the current research on the direct injection option but also examines some of the costs involved, the impacts on the marine environment, and the legal position. Copies are available without charge from the IEA Greenhouse Gas R&D Programme at the address below.

Those interested in member countries such as Canada may also access *Retrofit of Power Stations to Reduce Carbon Dioxide Emissions* (Report PH4/7) that models some 22 retrofit options for power stations. A report accompanies the model (written in Microsoft Excel) which includes descriptions and background information on the retrofit options and instructions on how to use the model.

In a related activity, the Fossil Fuel Working Party of the International Energy Agency has begun a new research initiative to study the possibility for the development of the zero emission technologies (ZETS) as applied to the fossil fuels. Information on ZETS may be found on the Web at www.iea.org/impagr/zets.

Copies of the Anniversary Report, the bi-monthly news publication `Greenhouse Issues', and the Annual Report may be obtained from the IEA Greenhouse Gas R and D Programme, CRE Group Ltd., Stoke Orchard, Cheltenham, Gloucestershire, U.K. GL52 4RZ. (Fax: +44 (0) 1242 680753; E-Mail: mail@ieagreen.demon.co.uk)

Water Resources Chapter of *Climate Change Impacts and Adaptation*

The report *Climate Change Impacts and Adaptation: A Canadian Perspective* provides a summary of research in this field over the past five years as it relates to Canada. The underlying premise is that notwithstanding efforts to reduce greenhouse gas emissions by such international agreements as the Kyoto Protocol, significant changes will occur in any case to which adaptation will have to be the main response. Sections of this report will be posted on the Web as they become available and the Water Resources chapter was mounted in August 2002. This chapter is of interest to the energy field because of the magnitude of the effects expected from climate change over the century, and because of direct effects on the industry itself which include the reduction in hydroelectric potential in some regions of the country, adverse effects on the supply and temperature of condenser cooling water in others, and limitations imposed upon navigation on the Great Lakes.

The Chapter reviews previous work, notes the impact on the quantity and quality of water supply, catalogues ecological effects, deals with water demand, and then proceeds to consider adaptation in the water resource sector. The complexity of the subject is noted in that the frequency of both drought and flood conditions are expected to increase with climate change, and that both extremes introduce problems with water quality. The sixteen-page report provides 60 references to current research on this subject. Copies of the Water Resources Chapter may be obtained from the Climate Change Impacts and Adaptation Directorate,
Natural Resources Canada, 601 Booth Street, Ottawa, Ontario, K1A 0E8
E-Mail: dlemmen@nrcan.gc.ca
http://adaptation.nrcan.gc.ca/pdf/perspective_chap3.pdf.

Discussion Paper on Canada's Contribution to Addressing Climate Change

On 15 May 2002, the Hon. David Anderson, the Minister of the Environment, released *A Discussion Paper on Canada's Contribution to Addressing Climate Change* (ISBN 0-662-32176-6) which was prepared to identify a range of options and issues that will lay the foundation for consultations with provincial and territorial governments, industry, and others interested in this vexing and complex issue. This paper was the result of a commitment made by the Federal government to the Joint Meeting of Ministers of Environment and Energy (JMM) with the twin objects of `developing a reasonable approach to addressing climate change that places no unreasonable burden on any region' and `to develop a plan that has the benefit of input from the Provinces and Territories, stakeholders and the public.' The paper was the basis for the presentation of the federal position at the JMM Meeting held in Charlottetown on 21 May, and the consultations held with 900 stakeholders in 14 cities across the country from 7 – 21 June 2002.

The Discussion Paper is 54 pages in length and includes three appendices. It opens with a useful review of the situation and of the progress made to date including a definition of terms. It proceeds to a section entitled `What we have concluded' that explains the origin of the `gap' of 240 million tonnes of carbon dioxide that must be addressed. The economic impact was estimated by the Analysis and Modelling Group (AMG), a federal-provincial-territorial working group created to focus on analytic priorities. Recent estimates prepared by the AMG and based upon possible policy approaches place the impact of reaching the Kyoto Protocol target at between 0 and –2 percent of GDP by 2012. A detailed explanation of these calculations appears in Appendix 1 of the report. The authors note that there are three main policy instruments Canada could use to meet its objectives: (1) domestic emissions trading; (2) targeted measures; and (3) government purchases of international permits.

The Discussion Paper than proceeds to outline four options. Option 1 is based upon a domestic emissions trading scheme that relies mainly on market mechanisms implemented as broadly as practicable. Option 2 involves all `targeted' measures that are built around government programs or initiatives. Option 3 is a mixed approach involving a combination of domestic emissions trading by `large final emitters', but including targeted measures and the government purchase of international permits. Option 4 is an adjusted mixed approach which differs from Option 3 in that the method of allocating permits would be specifically designed to ease competitiveness concerns. Companies would also have the opportunity to purchase emission reductions or `offsets' from firms outside the trading system. Targeted measures would be extended to help achieve other economic, social and environmental goals. The paper elaborates the advantages and disadvantages of these four options, and it is clear the final decision on signing the Kyoto Protocol will depend on one or other of these options.

Copies of the Discussion Paper may be obtained from the Climate Change Secretariat, 55 Murray Street, Ottawa, Ontario, K1N 5M3 (Tel: 1 800 622-6232) or downloaded from the Web in .pdf form at www.climatechange.gc.ca/.

Alberta Plan for Action on Climate Change

In May of 2002, the Province of Alberta released Albertans and Climate Change: A Plan for Action described as a `Draft for Discussion' which was also discussed at the Joint Meeting of Ministers of Environment and Energy in Charlottetown 21 May. It complements an earlier document *Albertans and Climate Change: A Strategy for Managing Environmental and Economic Risks*. These documents have been prepared to present, in the view of that government, a meaningful alternative to Kyoto based upon a technologically-driven solution. There have been extensive consultations with stakeholders in the province throughout the summer with the intention of arriving at a final version of the Plan by December of 2002.

The Alberta documents differs from the Federal position in that the objective is to reduce the intensity of emissions with respect to GDP by 50% by 2020, a later date than provided in the first stage of the Kyoto Protocol. Emissions are expected to increase to about 220 megatonnes of carbon dioxide by 2020 as compared to 171 megatonnes in 1990. Much of this expected increase will come from the expansion of the oil sands industry. Nevertheless, the Action Plan calls for more significant emissions reductions over the longer term to 2050. Though there are significant proposals in such fields as energy conservation and the removal of carbon dioxide from the atmosphere through the use of forestry and agricultural sinks, the Plan emphasizes technological options such as carbon capture and sequestration in the oil industry. It is planned to demonstrate that carbon dioxide can be stored in geological formations including applications for enhanced oil recovery and the extraction of methane from coal beds.

The specific action items are listed as:

- Facilitate and negotiate agreements with specific economic sectors, including electricity, oil and gas, transportation, forestry, municipalities and other industries to gain commitment for action for reducing greenhouse gas emissions;
- Implement a mandatory greenhouse gas emissions reporting program for large emission sources;
- Lead by example through action within the Government of Alberta;
- Facilitate access to electricity generated from a diversity of energy sources and energy conservation alternatives;
- Demonstrate leadership and reduce operating costs by promoting and implementing energy efficient options for government operations;
- Create awareness and choices for the adoption of energy conservation opportunities by Albertans;
- Encourage innovation through demonstration or by encouraging action;
- Explore the use of biological sinks (agricultural soils and forestry) in Alberta as part of the Alberta strategy for addressing climate change;
- Address stakeholder uncertainty;
- Establish a provincial GHG emissions trading framework;
- Overcome permanence and liability issues;
- Establish an adaptation research program including collaboration with other governments in Canada;
- Help Albertans explicitly address the risks of short-term climate variability and extremes notably in the management and planning for agriculture, forestry, health, municipalities, infrastructure and water;
- By 2010, prepare Albertans to deal with longer-term climate changes as a result of developing scenarios; assess the ability of our natural systems, economy and institutions to adapt; develop options, make investments and implement

appropriate changes;

- Keep Albertans informed of the risks and opportunities of climate change and engage then in adaptation efforts.

On 17 October 2002, the Province released another report in this series entitled *Albertans and Climate Change: Taking Action.* Specific measures were listed under the following headings: Negotiate agreements with key sectors; Emissions trading; Put the Alberta government 'house' in order, Help Albertans conserve energy; Support technology; Carbon management; Renewable/alternative energy sources; Biological sinks; and Adapting to climate change.

Albertans and Climate Change: A Plan for Action may be downloaded at www3.gov.ab.ca/env/climate/actionplan/docs/actionplan.pdf.

Energy and Climate Change

The Canadian Academy of Engineering has released a report entitled *Energy and Climate Change – A Canadian Engineering Perspective* prepared by a Working Group Chaired by Jozinus (Joe) Ploeg formerly of the National Research Council. Its purpose was to examine the many views and papers already published on this subject, and to determine what role the Academy could play to advance the general understanding of this issue.

The report concludes that 'hydrocarbon–based energy sources should be able to satisfy the six-fold increase in the demand for energy which is forecast for this century. However, the risk that such a strategy would have significant effects on the climate, and therefore on the global environment, is probably too large to accept. A long-term, sustainable energy strategy needs to be developed, which will necessarily require a larger choice of energy sources and energy technologies than presently available. Given the immense challenges of developing energy technologies and the collective expertise of the members of the Canadian Academy of Engineering, it is evident that the Academy can play an important role in the assessment of those already available, as well as entirely new energy technologies.' It is the intention of the Academy to pursue this subject into a second phase with a focus on the assessment of existing and emerging energy technologies.

This report of 18 pages (ISBN: 0-9682770-9-8 with French version attached) may be obtained from the Academy at 180 Elgin Street, Suite 1100, Ottawa, Ontario, K2P 2K3 (E-Mail: acadeng@ccpe.ca; Fax: (613) 235-6861).

U.S. Climate Action Report - 2002

Though it is no longer a full participant in the Kyoto Process, the United States has submitted the *U.S. Climate Action Report – 2002* as the Third National

Communication of the United States of America Under the United Nations Framework Convention on Climate Change in compliance with Articles 4 and 12. When it was mounted on the Web, there was considerable media coverage on 3 June 2002 suggesting there had been a change in policy in the U.S. because this report generally acknowledges anthropogenic causation of observed warming and implies that adaptation will be the primary means of dealing with the situation. Though mounted on the EPA Web Site, this document is to be cited as `U.S. Department of State, U.S. Climate Action Report 2002. May 2002'. The report of 268 pages is of interest because the U.S. is the source of about 25% of world anthropogenic emissions of greenhouse gases.

The Action Report is prepared in standard FCCC format with the titles of the nine chapters respectively: (1) Introduction and Overview; (2) National Circumstances; (3) Greenhouse Gas Inventory; (4) Policies and Measures; (5) Projected Greenhouse Gas Emissions; (6) Impacts and Adaptation; (7) Financial Resources and Transfer of Technology; (8) Research and Systematic Observation; and (9) Education, Training and Outreach. The five Appendices include `Climate Change Science: An Analysis of Some Key Questions' and a useful bibliography. The emissions projections in Chapter 5 do not, however, include the Presidential climate change initiative announced in February 2002, which is essentially technological in character, nor the effect of measures of the National Energy Policy that have not as yet been implemented. Chapter 6 provides an overview of potential negative and positive impacts and possible response options at the regional and local levels. It is this section that has attracted particular attention with its final sentence: `Although changes in the environment will surely occur, our nation's economy should continue to provide the means for successful adaptation to climate changes.'

Copies of the *U.S. Climate Action Report – 2002* may be downloaded from the Web at www.epa.gov/globalwarming/publications/car/index.html either chapter-by-chapter in .pdf form or completely as a single zipped .pdf file.

A U.S. View of Canada's Oil and Gas Potential

The *Hubbert Center Newsletter #2002/2* mounted on the Web at the M. King Hubbert Center for Petroleum Supply Studies at the Colorado School of Mines in Golden, Colorado, contains two reviews of the Canadian oil and gas situation. L.F. Ivanhoe, in a section entitled *Canada's Future Oil Production: Projected 2000-2020*, after a survey of the situation concludes: `Canada's oil production from wells and tar sands should cover all of Canada's needs while maintaining current exports to the U.S. through 2020. Increased exports to the U.S. may depend on converting large volumes (= 0.2 billion barrels per year) of `Bitumen'/Tar into Synthetic Crude Oil. Use of natural gas as the principal sources of heat to produce Synthetic Crude Oil will decrease the amount of gas available for export to the U.S.'

Joseph P. Riva, in a section entitled *Canadian Gas, Our Ace in the Hole?*, takes note of the work of the Canadian Gas Potential Committee in reaching his conclusions. These he summarized by writing: 'As the U.S. struggles to find sufficient domestic production to meet the escalating demand for natural gas for new power plants as well as for residential, commercial, and other industrial needs; as in the past there likely will be a turn to Canada for increasing gas imports. Only this time Canada will be struggling too, trying to meet its increasing gas demand with a relatively modest and widely dispersed gas resource. The Canadian ace in the hole could become a joker. As for all those U.S. gas fired power plants, it would be very wise to build them with a fuel switching capability.'

The Hubbert Center Newsletters may be downloaded:
http://hubbert.mines.edu/

Testimony of Matthew R. Simmons to the U.S. House of Representatives

Mr. Matthew R. Simmons, President, Simmons and Company International, an investment bank that has specialized exclusively in energy investment banking and allied activities for many years, testified to the Sub-Committee on Energy and Mineral Resources of the U.S. House of Representatives on 16 July 2002 on the prospects for natural gas in the U.S. The essence of his position is that 'Natural gas demand must grow even faster than once thought in order for America to increase its electricity use while supply continues to stay flat as it has done for the past eight years, despite a natural gas drilling boom of historical proportion in both the U.S. and Canada. There is now a grave chance that natural gas supplies will fall beyond the 3 to 5% drop seen so far. ... Suddenly the concept that gas supplies could grow to even partially meet the demand in the magnitude of 30 TCF a year is becoming a remote dream. If supply falls by as much as 10%, and the drop could be far worse, this could become America's most serious energy wake-up call since the 1973 Oil Shock.' He notes that U.S. gas well completions totaled 15,600 in 2000 but supply barely grew. He provides a detailed analysis of current drilling in Texas where the decline rates for new wells have been high by historical standards. He goes on to draw implications for what he regards as the excessive dependence on the generation of electricity from natural gas. Mr. Simmons' testimony is entitled *The Growing Natural Gas Supply Imbalance* is available on the Web at www.simmonsco-intl.com/.

New Book on the Chemistry of Radioactive Waste Management

Professor Donald R. Wiles, an expert on radiochemistry at Carleton University in Ottawa, has written *The Chemistry of Nuclear Fuel Waste Disposal* (ISBN 2-553-01025-7) published in 2002 by Polytechnic International Press of Montreal. The ten chapters of this new book are titled: Introduction; Nuclei and Radioactivity; Nuclear Reactions and Reactors; The Spent Fuel; Proposed Management Methods; Geological Disposal; The Critical Processes; Forecasting the Impact; Final Comments; and The Last Word with the subheading `Proof of Burial's Not So Easy.' There are number of useful appendices. The object of the author was to provide information and easily understood explanations of the processes involved in radioactive waste management, the areas of certainty and uncertainty, and the basis for statements about risk and safety to human and other life over time. The book is timely now that under the legislation that has now come into effect, the nuclear industry has until 2005 to choose its waste management options. The Web Site of Polytechnic International Press is http://www.polymtl.ca/pub.

Second Edition of the CD-ROM *CO_2 and Energy*

The Statoil Company of Norway has now produced a second edition of its CD-ROM *CO_2 and Energy*. This CD-ROM provides a description of the Sleipner gas field project in the North Sea covering the separation of the carbon dioxide from the natural gas produced and its storage in a deep saline reservoir. An outline of the project established to monitor the fate of the carbon dioxide in this, the world's first sequestering operation at an industrial scale, is also included. The CD-ROM contains an illustration of the company's vision of a CO_2-free energy economy based upon electricity and hydrogen as energy carriers. A copy of the IEA greenhouse gas `what-if' model called *Merlin* is included. An animation section has been prepared for educational purposes. Copies of this CD-ROM may be obtained without charge from Astrid Fjell of Statoil at asfj@statoil.com.

Newsletter of the International Association for Energy Economics for the Third Quarter of 2002

The IAEE Newsletter for the Third Quarter of 2002 contains a study of U.S. gasoline markets fragmented by differing environmental requirements by Barry Posner entitled *Market Fragmentation and Gasoline Price Shocks: An Investigation*. Other papers include: *Caspian Sea is No Middle East* by Mamdouh G. Salameh; *Modeling the Economic Impacts of Offshore Activities in the Alaska Arctic* by Jonathon Skolnik and Chris D. Holleyman; and *Sobering Realities of Liberalizing Electricity Markets* by Fereidoon P. Sioshansi.

Copies of the Newsletter may be obtained from the IAEE at 28790 Chagrin Boulevard, Suite 350, Cleveland Ohio, 44122. (Fax: (216) 464-2737; E-Mail: IAEE@IAEE.org)

Short Notes

At the *World Summit on Sustainable Development*, held in Johannesburg from 28 August to 4 September 2002, the Prime Minister announced that, following further consultations with the Provinces, industry, and other stakeholders, he would submit the Kyoto Protocol to Parliament with the goal of ratification by year-end. The credit for `clean energy' exports and some other issues remain outstanding. This intention was further confirmed in the Speech from the Throne presented on 30 September 2002. Japan and the European Union have ratified the Kyoto Protocol and Russia has announced its intention to do so though Australia has decided against. The Conference also called for increased reliance on renewable energy sources but set no specific targets.

The Executive Board of the Clean Development Mechanism of the UN Framework Convention on Climate Change has mounted its *Project Design Document* on the Web at http://unfccc.int/cdm.

The *Canadian Association for Energy Economics* (CAEE) was formally established as a component of the International Association for Energy Economics (IAEE) at its Aberdeen meeting in June of 2002. The first meeting under the new name was held in Vancouver at the AIEE North American Conference 6 –8 October 2002. Professor André Plourde of the University of Alberta, a former Editor of the ESR, is the first President. For further information contact andre.plourde@ualberta.ca; the IAEE at www.iaee.org; and the CAEE at www.iaee.org/en/affiliates/canada.asp?ID=4.

The National Energy Board in September of 2002 denied an application from the Province of New Brunswick in which the province had requested that the Board establish rules which would apply when it considers applications for short-term export orders for incremental supplies of Scotian offshore natural gas if those supplies cannot meet both domestic and export requests for service. The Board decided that such measures would unduly interfere with the normal operation of the market for natural gas and impose an additional regulatory burden that would send a negative signal to investors in the Scotian offshore basin. The Board did agree, however, that there were characteristics of the Maritime gas market which give rise for concern. For this reason, the Board will form a team to monitor the market situation that is to prepare its first report before 31 July 2003. The Board will also publish additional data based upon the monthly reports of export order holders in aggregate form with the object of improving price transparency in this market.

Marathon Oil reported a deepwater hydrocarbon discovery off the coast of Nova Scotia.

Large quantities of methane held in the form of frozen hydrates (clathrates) have been found off the coast of British Columbia southwest of Vancouver Island. No method of exploitation has yet been successful for commercial recovery of this abundant source of methane found around the world.

Canada now obtains some 17 percent of its primary energy supply from renewable sources and ranks second among the OECD nations in this regard. It is the largest generator of hydroelectricity in the world. The Federal government spends about $15 million per year on developing the new renewable sources and this figure is expected to increase to about $50 million annually over the next few years. This support will be provided in the fields of technology innovation, support for producers, market development, and tax incentives.

It was announced at the annual meeting of provincial premiers in Halifax in August that an agreement in principle had been reached between Newfoundland and Quebec to build the 2000 MW Gull Island hydroelectric project in Labrador. Construction could start in three years with completion expected in 2012. Cost was given as $4 billion.

A unit of Atomic Energy of Canada Ltd., AECL Technologies Inc has announced plans to introduce the Advanced CANDU Reactor (ACR-700) in the U.S. market. This 700 MWe class light-water-cooled reactor has been designed to lower costs and enhance safety and plant security and is offered as competitive with gas-fired combined-cycle generation. The ACR-700 is an evolution of the 700 MWe-class CANDU-6 reactors now under construction in China and Romania. Costs are reduced by introducing innovative construction techniques, light water for cooling, and slightly enriched uranium fuel. Overnight capital cost is placed at $1000/kWe. The new design draws upon the extensive experience with existing CANDU technology. President Bush signed the bill establishing the nuclear waste repository in Yucca Mountain in Nevada on 23 July 2002 following its passage in the Senate on 9 July 2002 after 20 years of debate. The opponents of this first major facility for the long-term storage of high-level wastes from the nuclear power industry and other sources in the U.S. plan to continue their opposition in the courts. If the remaining regulatory and legal hurdles can be overcome, the facility will open in 2010. Opposite views of this proposal entitled *Yucca Mountain Pro and Con* appeared in the October 2002 issue of the IEEE journal `Spectrum' (Vol. 39 Number 10) (Web: www.spectrum.ieee.org)

The Governor of California, Gray Davis, signed the California Climate Bill on 22 July 2002 which for the first time gives the California Air Resources Board the power to limit the emissions of carbon dioxide. This act is important because it is the first specific U.S. legislation aimed at climate change. The State is both an important source of emissions in the U.S. and the largest market for cars in the country. In general, fuel efficiency standards for vehicles have been ruled in the orbit of the federal government but the courts have permitted states to enact local restrictions on the emissions of pollutants. The measure would not be effective until 2005 and would first affect cars produced for the 2009 model year. The legislation was strongly opposed by automotive interests on the grounds of increase in costs to consumers and insufficient time allowed to introduce major changes in motive power.

The Alberta Research Council will lead a consortium of companies to bring Canadian-developed enhanced coalbed methane recovery technology to China. The technology is being transferred as part of a jointly funded $10 million agreement signed between the Canadian International Development Agency (CIDA) and the Chinese Ministry of Foreign Trade and Co-operation. Carbon dioxide is sequestered when it is injected into deep unmineable coal beds to release methane. Trials are planned in Shanxi Province. The world's second largest coal producer after the U.S., China has a large resource potential of an estimated 333,000 billion cubic metres (11,750 TCF) of coalbed methane available 2,000 metres underground, and some six billion cubic metres (0.2 TCF) of methane are currently emitted to the atmosphere each year from conventional mining operations.

An article in `Technology Review' July/August 2002 (Vol. 105 No. 6) entitled *Wind Power for Pennies* deals with the prospects for light, backward-facing horizontal axis wind turbines which offer the possibility of important reductions in capital cost. (Web: www.technologyreview.com) A report on the largest offshore windfarm to date being built in Denmark entitled *Reap the Wild Wind* appeared in the October 2002 IEEE publication `Spectrum' Vol. 39 No. 10. (Web: www.spectrum.ieee.org)

Rapid progress in the field of magnesium diboride superconductors is reported in *The Sensible Superconductor* which appeared in the July 2002 IEEE publication `Spectrum' Vol. 39, No. 7. (Web: www.spectrum.ieee.org)

Electric Vehicles

Both the Honda Motor Company and the Toyota Company of Japan will be offering a limited number of fuel cell-equipped vehicles to companies and research groups with access to hydrogen-fuelling facilities on a lease basis as soon as late 2002. The Honda Civic FCX has a range of 350 km with hydrogen stored in pressurized containers. It is the first fuel cell-equipped car to receive certification from U.S. and California environmental regulators. The Toyota Company will be offering a hybrid sports utility vehicle.

An Ottawa company, Energy Visions Inc., has announced it has combined direct methanol fuel cells with nickel-zinc batteries to power electric vehicles. The fuel cell does not require the prior reforming of methanol. The advantages of this hybrid system as compared to all-battery systems include lower cost, less weight, and no downtime required to recharge.

Both General Motors Corporation and the Ford Motor Company have announced the cessation of production of certain battery-only electric vehicles.

An article in the October 2002 issue of *Scientific American* entitled *Vehicles of Change* by Lawrence D. Burns, J. Byron McCormick and Christopher E. Burroni-Bird deals with the possibilities for fuel cells in cars and the transformation of the energy infrastructure that would result from their widespread adoption. (Web: www.sciam.com)

Energy Studies Review Vol.11, No. 1, 2003 pp.114-130

Optimal Inter-Sectoral Allocation of Natural Gas in Iran

Shahla Khaleghi

ABSTRACT

Some special characteristics of Natural Gas (NG) from both an economic and an environmental point of view have made it an important energy-input in production and intermediate sectors and also, a suitable potential energy source in all economic sectors. These characteristics will be important factors contributing to increasing trends in NG consumption.

Increased usage of NG could be a long-term policy objective in terms of development goals, especially in countries with rich NG endowments such as Iran. However, analysis of the comparative advantage of NG consumption in the domestic economy must be taken into consideration.

This study shows that the utilization of NG has a comparative advantage for the Iranian economy. The injection sector demonstrates the highest value within the economy. The industrial sector is the second most valuable, while electricity generation and residential/commercial sectors are third and fourth, respectively. Finally, the study shows that NG, although it has comparative advantages in the domestic economy, could be exported when demand has been met for injection projects and domestic consumption.

Shahla Khaleghi is an Energy Economist-senior expert of planning at the National Iranian Gas Company, Corporate planning Department

The main objectives of this paper are the evaluation of the comparative advantage and optimal inter-sectoral allocation of NG in Iran. In the first step, we will undertake a theoretical review of comparative advantages and optimization of NG consumption indices as well as estimates of these indices in different economic sectors. Priority of inter-sectoral NG will be an important result of this study. We will compare this result with NG consumption pattern in Iran.

Natural gas consumption in Iran has increased six fold in the past fifteen years (from 9.7 bcm in 1985 to 57.8 bcm in 1999) and is forecasted to enjoy continued robust growth in the future (Fig.1). As such, evaluation of the comparative advantage of natural gas (NG) in different economic sectors should be considered as the first step in energy policy making. Accounting for comparative advantage is one of the important building blocks for the optimal allocation of gas supply within the economy.

The main criteria for determining the relative advantage of NG are the Domestic Recourse Cost (DRC) and the Resource Cost Ratio (RCR) indices. They usually are discussed in relation to international trade issues, such as defining the value of producing for exports. The DRC method can be used as a practical criterion for opportunity cost in the economy. This method is very similar to cost-benefit analysis. The difference is that, the latter compares real cost with benefit while the DRC method net domestic resource cost is compared with the net foreign exchange conservation.

The DRC of NG can be used as the opportunity cost of domestic resources, which can be used to arrive at the international value added from domestic input in a specific activity (domestic currency that might be paid in exchange for foreign currency which is saved - in this study exchange rate is considered to be 8000 Rls/$). This index in comparison with shadow price of exchange rate (SER) can be a criterion for comparative advantage analysis of gas. NG will have relative advantage where DRC < SER.

$$DRC_i = DC_i / NVA_i$$
$$DRC < SER$$

DC_i: domestic opportunity cost of input in i_{th} activity in exchange for each product NVA_i: international value added of domestic input in i_{th} activity in exchange for each product.

Resource Cost Ratio (RCR) is other index, which is used to assess the comparative advantage of NG. This is calculated by the ratio of DRC over shadow price of exchange rate. NG will have relative advantage where RCR < 1

$$RCR = DRC / SER$$
$$RCR < 1$$

The sectors that we examine in this study are residential/commercial, industry, power plant, injection and exporting. It is worthwhile to note that the injection sector consists of gas injected to oil fields to preserve of oil reserves and maintain steady oil production capacity.

The studies show that the weighted average of DRC in all of sectors (Residential/Commercial, Industry, Power Plant, Injection and Export) was 390.7 RLS/$ that is saved. It is worthwhile to note that the DRC of Residential/Commercial, Industry, Power Plant was 675 RLS/$. Comparing DRC with SER (that is 8000 RLS/$) shows that there is a relative advantage for domestic NG use.

On the other hand, the RCR index was .049 in all sectors and in the first type basket gas was .084. With regard to this study, we concluded that the relative advantage of natural gas in the economy as a whole is very crucial (Table1).

Favouring of gas consumption within different sectors, especially due to limited production and supply, is the second step toward the optimal allocation of gas; having a great deal of impact on the macro economy. Studying such a subject can be performed by evaluation of the NG consumption benefits in each sector, both in productive and in non-productive sectors (residential/commercial, industry, power plant, injection and exporting sectors).

The main criterion for inter-sectoral comparison is the Net Back (NB) index. This criterion generally indicates the economic efficiency of each unit of NG consumption. This index contains two variables including benefit and cost. In other words, it considers net benefits of each unit of gas by sector.

$NB_{gi} = PVB_{gi} / PVQ_{gi}$

NB_{gi}: The net back value of natural gas in sector i;
PVB_{gi}: The net present value of benefits in sector i;
PVQ_{gi}: The net present value of gas consumption in sector i;

The results of our study show that the injection sector has a higher relative value than the other sectors. This is because the NB index in this sector was higher than others in the scenario of not taking opportunity cost into account. It was 11.1 cent/cm in the former case. The NB indices of the industry and power plant sectors at 8.9 cent/cm and 8.5 cent/cm and were second and third in respective priority.

The NB index in the residential/commercial sector was 2.4 cent/cm less than power plant sector (6.1 cent/cm). The exporting sector, was one-third of the injection sector (4 cent/cm), therefore this sector was the last priority (Table2).

By taking into account the opportunity cost of natural gas, (although decreases the NB index in all sectors,) without changing the priority of gas consuming sectors, the NB index in injection, industry, power plant and residential/commercial sectors was 7 cent/cm, 6.4 cent/cm, 5.9 cent/cm and 3.5 cent/cm respectively. The index in the exporting sector decreased so much that it became negative. It is worthwhile to note that we consider the net benefit of NG consumption in national economy as the opportunity cost of exporting gas NG (Table3). This clearly suggests that domestic usage is more valuable than exporting.

Now, we focus on a discussion of the NG consumption basket in Iran. The comparative advantage of NG in Iran is an especially important factor in economic development and in forming the energy consumption basket. The substitution of NG for other kinds of energy, in addition to improving the self - sufficiency of the country will benefit social welfare.

In the last two decades, the average annual growth rate of NG consumption, 16%, has been more than twice the growth of the total Iranian energy consumption, 7%, whereas oil products consumption grew at a rate, 5%, lower than the total energy consumption.

Penetration of NG in the energy consumption basket has been rapid in this period. The share of NG in the total energy consumption basket increased from 10% in 1980 to more than 39% in 1999. The share of oil products decreased from 77% to 52% in this same period.

The analysis shows that, more utilization of NG in the national economy has been an important goal in energy policy in past decades. This is due to energy security, especially during and after the war (Fig1).

In these decades Iran has not had a role in the international NG market (as a gas exporter). On the other hand, gas injection to oil-fields has been considered a priority in energy policy in Iran, although financial problems and the condition of Iran in war periods were limiting factors.

In 1999, the power plant sector had a dominant role in the NG consumption basket. The breakdown of NG consumption was: Power plant 38.1%, Industry 28.5% and Residential/commercial 33.4.

But, in the third five-year plan, the share of industry in the NG consumption basket will increase considerably. By the end of this plan, 2004, its share should increase to 35.4% while the power plant share will decrease to 33.3% and the residential/commercial to 31.3%.

It is worthwhile to note, 31 power plants, more than 2200 industrial consumers, 150000 commercial consumers and 6 million Iranian households (45 % of total households) consumed NG in 1999. By the end of 2004 it is expected that nearly 80% of Iranian households will be supplied by NG (Fig2&3).

Conclusion

This study shows that at the present time domestic utilization of NG has a comparative advantage for the economy of Iran. Therefore, a strategic policy of NG substitution, (for other conventional energy carriers), that meets long-term national benefits should be considered by energy decision makers. Evaluation of the NB index for NG in different consuming sectors indicates that the injection sector has the first advantage with respect to other economic sectors. Preservation of oil reserves and keeping the steady capacity of oil production and in turn oil revenue, in order to benefit the Iranian economy, which is closely dependent on oil, is still very crucial.

The industry sector would be second in priority, while power plant and residential/commercial sectors would be in third and fourth respectively. The study also shows that NG (although it has a comparative advantage in the domestic economy) could be exported when it has met the required supply for injection projects and domestic consumption.

References

Julius, D. & Mashayekhi A., "The Economics of natural gas, pricing, planning, and policy" *Oxford University*, 1990

Siddayao, C.M., "Is the net back value of gas economically efficient?" *OPEC Review*, sep.1997

"Annual report of national Iranian gas company", 1997&1998

"Energy statistical bulletin", *Ministry of energy*, 1998

"Power system economics, the value of natural gas in electricity generation", *Energy Economics*, oct.1984

Appendix I

Optimal Allocation of Natural Gas Consumption in Sectors in Iran

Relative advantage of natural gas has been evaluated by Domestic Recourse Cost (DRC) and Resource Cost Ratio (RCR) indices. These indices are due to the opportunity cost of domestic resources, which can be used to arrive at an international value added from domestic input (gas) in a specific activity (gas replace for another liquid fuels).

$$DRC_{igt} = DC_{igt} / NVA_{igt}$$
$$DC_{igt} = TLC_{igt} - TLB_{igt}$$
$$NVA_{igt} = TFC_{igt} - TFB_{igt}$$

DC_{igt}: Domestic opportunity cost of input (gas) in i_{th} activity in exchange for each product;
NVA_{igt}: The international value added of domestic input (gas) in i_{th} activity in exchange for each product;
TLC_{igt}: Total local currency (Rial) costs attributable to gas;
TLB_{igt}: Total local currency (Rial) benefits attributable to gas;
TFC_{igt}: Total foreign currency ($) costs attributable to gas;
TFB_{igt}: Total foreign currency ($) benefits attributable to gas;
All costs and benefits attributable to gas in each sector will be explained in detail later.
The DRC index compares with the shadow price of exchange rate (SER). Three conditions apply:

1. Natural gas has a relative advantage where SER > DRC
2. No difference between fuels where SER = DRC
3. Natural gas does not have a relative advantage where SER < DRC

The government in Iran has controlled exchange rates up to now. Therefore we have two kinds of exchange rates in Iran, the controlled exchange rate and the free exchange rate, which is determined in the free (or black) market and is affected by real market demand. We consider the exchange rate in the free market to be the shadow price of the exchange rate.

Benefits attributable to gas are defined as the excess of overall project benefits when gas is preferred to the next-best alternative. This general definition is best illustrated by referring to the five possible cases: a) when gas replaces other fuels or feedstock in domestic production; b) when gas is used to produce something that would otherwise be imported; c) when gas produces another energy (e.g. electricity); d) when gas is directly or indirectly exported; and e) when gas is used to preserve the oil fields (gas injection).

In this article we focused on the first case of gas usage, when gas replaces other fuels in each of the consumer sectors.

It is often more convenient to express the gas benefits in terms of benefits per unit of gas consumed over time. This is referred to as the "netback" value in each use. This use of the term "netback" is distinct from the concept of netback pricing of crude oil. The only similarity is that both derive a value of an input (oil, gas) from the value of the end product.

The netback is calculated by dividing net present value of total benefits attributable to gas to present value of consumed gas in each sector:

$$NPVB_{gt} = S_{t=1}\,[CF_{at} - (I_{gt} - I_{at}) / (1+r)^{t}]$$
$$PVQ_{gt} = S_{t=1}\,[Q_{gt} / (1+r)^{t}]$$
$$NB_{gt} = NPVB_{gt} / PVQ_{gt}$$

B_{gt}: The benefits of natural gas are consumed by sector;
$NPVB_{gt}$: The net present value of the natural gas benefits in each sector;
CF_{at}: The value of substitutable fuels by gas and other costs which are attributed to them (transportation, storage, ... costs);
I_{gt}: Required investment and operation & maintenance costs of supplying gas to consumers;
I_{gt}: Required investment and operation & maintenance of costs supplying substitutable fuels (kerosene, gas oil, fuel oil...) by gas to consumer;
Q_{gt}: Natural gas consumption in each sector;
PVQ_{gt}: The present value of natural gas consumption in each sector;
NB_{gt}: The net back index in each sector;
t: Time (life of the project);
r: Discount rate;

As defined above, the gas netback could also be called Average Incremental Benefit (AIB) of gas use. In this case, the economic netback value of natural gas is defined as the amount the consumer saves on alternative fuel, compared to what the consumer would have purchased when gas was not available.

This index is defined for each of the gas consumer sectors, regarding the total cost attributable to end user (including upstream and downstream costs for each consumer unit, pipe-laying cost of each consumer unit, cost of converting appliances to gas, purchasing cost of new appliances, all fees the consumer should pays to the supplier (e.g. subscription fee) and purchasing cost of all equipment necessary for gas injection).

We estimated the gas substitution income based on the value of energy mix replaced by natural gas in each sector and in different scenarios. The income scenarios or gas opportunity incomes are estimated on the basis of:

1. The value of substituted energies basket in 1997
2. The value of substituted energies basket in 1998
3. The value of substituted energies basket during the 1994-1997

All information about technical and economic parameters (income, characteristic of system...) was considered in the base year of 1997 in the first scenario and the year 1998 in the second and third scenarios.

Residential and commercial sectors

The natural gas used by residential and commercial sectors displaces liquid fuels such as kerosene, gas oil, fuel oil and LPG. Regarding the import prices of energy carriers and the share of each of them in its energy mix, the structure of replaced energy consumption mix by natural gas in residential and commercial sectors is as follows:

(%)

Fuel/Year	1997	1998	1994-1997
Kerosene	51.2	53.1	51.4
Gas oil	19.6	17.6	18
Fuel oil	12.9	10.2	15.1
LPG	16.3	19.1	15.6
Total	100	100	100

The value of its energy mix in different scenarios is as follows:

First scenario: 18.5 $/bbl

Second scenario: 13.5 $/bbl

Third scenario: 20.1 $/bbl

The supply costs of gas to the residential and commercial sectors include both non-customer- related and customer-related costs. Non-customer- related costs consist of upstream (exploration and production) costs, downstream (refining and transmission) costs and distribution costs (including costs of network, extensions, city gate stations-CGS, and town board stations-TBS). Distribution costs vary with the network's configuration, (the extent and length are functions of housing density).

Customer-related costs are affected by the number of customers, type of housing and volume of consumption. These costs include gas pipe-laying for the house or apartment (equip housing units for gas, customer regulator, meters, costs of converting them to the gas supply system or costs of new appliance and all fees that consumers should pay to the supplier, e.g. subscription fee, connection fee...). We took into account net value of natural gas export as opportunity cost of gas consumption in residential and commercial sectors. The net back formulation in residential and commercial sectors is as follows:

$$NPVB_t^{RC} = S_{t=1}[(SEM_t^{RC} + TCE_t^{RC} - NCRC_t^{RC} - CRC_t^{RC} - OCG_t^{RC})/(1+r)^t]$$

$$PVQ_t^{RC} = S_{t=1}[Q_t^{RC}/(1+r)^t]$$

$$NB_t^{RC} = NPVB_t^{RC}/PVQ_t^{RC}$$

B_t^{RC}: The benefits of natural gas consumed by residential and commercial sectors;
$NPVB_t^{RC}$: The net present value of the natural gas benefits in residential and commercial sectors;
SEM_t^{RC}: The value of energies mix replaced by gas;
TCE_t^{RC}: The transportation costs of replaced energies;
$NCRC_t^{RC}$: The non-gas customer- related costs;
CRC_t^{RC}: The gas customer- related costs;
OCG_t^{RC}: The opportunity cost of gas consumption;
Q_t^{RC}: The gas consumption in residential and commercial sectors;
PVQ_t^{RC}: The present value of gas consumption in residential and commercial sectors;
NB_t^{RC}: The netback index in residential and commercial sectors;

We used the costs and benefits as mentioned above, for calculation of DRC and RCR in these two sectors and other sectors. Therefore we separated the local and foreign costs and benefits and then estimated these indices.

Industry sector

There are three main uses of gas in the industry sector. The first is as a fuel for producing steam, metalworking, process heat for cement, etc. The second use of gas is as a feedstock in the production of petrochemical products. The third use of gas in the industrial sector is the production of methanol (this use of gas is not conventional as are the first two uses). Methanol is an important chemical intermediate good and has potential as a substitute for gasoline.

In this study, we considered the first main application of gas as a fuel. In the industry sector gas mainly competes with gas oil and fuel oil. The structure of replaced energy consumption mix by natural gas in this sector is as follows:

(%)

Fuel/Year	1997	1998	1994-1997
Gas oil	29.1	26	32.1
Fuel oil	70.9	74	67.9

The value of its energy mix in different scenarios is as follows:
First scenario: 15.2 \$/bbl
Second scenario: 10.4 \$/bbl
Third scenario: 16.2 \$/bbl

The supply cost of gas to the industry sector was divided into two categories:

1. Non-industry-related costs including: upstream (exploration and production) and downstream (refining and transmission) costs;
2. Industry- related costs including pipeline cost which it has allocated to each of industry that switched to gas, and connected it to the domestic gas transmission system, city gate station (CGS) cost, converting appliance cost and all fees that each industry should pay to the supplier (e.g. subscription fee, connection fee...);

We took into account net value of natural gas export as the opportunity cost of gas consumption in the industry sector. The industry sector can reduce capital and maintenance costs of handling and storage of liquid fuels which gas replaced. The netback formula in the industry sector is as follows:

$$NPVB_t^I = S_{t=1} [(SEM_t^I + TCE_t^I - NIRC_t^I - IRC_t^I - OCG_t^I + CMS_t^I)/(1+r)^t]$$
$$PVQ_t^I = S_{t=1} [Q_t^I / (1+r)^t]$$
$$NB_t^I = NPVB_t^I / PVQ_t^I$$

B_t^I: The benefits of natural gas are consumed by industry sector;
NPVBtI: The net present value of the natural gas benefits in the industry sector;
SEM_t^I: The value of substituted energies mix by gas;
TCE_t^I: The transportation costs of substituted energies;
$NIRC_t^I$: The non-industry- related costs of supplying gas;
IRC_t^I: The industry - related costs of supplying gas;
OCG_t^I: The opportunity cost of gas consumption;
CMS_t^I: The capital and maintenance costs saved (because of reducing liquid fuels storage);
Q_t^I: The gas consumption in the industry sector;
PVQ_t^I: The present value of gas consumption in the industry sector;
NB_t^I: The netback index in the industry sector;

Power plant

We can consider the netback value in the power plant sector from two aspects: a) evolution of netback value without considering the configuration of the power plant system. It is estimated based only on conventional technology, b) evolution of the netback value considering configuration of the power plant system. For example, economic comparison of two power plants (by netback index), combined cycle and steam technology, is as follows:

{Net present value [(capital + fuel oil costs + operation costs of gas consumption) - (capital + operation costs of combined cycle)]} / (Net present value of gas consumption)

In this case, the net back value is a criterion for selection of power plant technology and its fuel pricing. Due to the purpose of this study (comparing relative advantage and economic value of natural gas in all consuming sectors), we consider the netback value from the first viewpoint.

In the power plant sector gas mainly competes with gas oil and fuel oil. The structure of replaced energy consumption mix by gas in this sector is as follows: (%)

Fuel/Year	1997	1998	1994-1997
Gas oil	14.2	14	14.9
Fuel oil	85.8	86	85.1

The value of its energy mix in different scenarios is as follows:

First scenario: 14.1 \$/bbl

Second scenario: 9.9 \$/bbl

Third scenario: 14.9 \$/bbl

The cost components attributable to switching power plants and industries from conventional fuels (kerosene, gas oil, fuel oil...) to natural gas and with the same netback formula.

Injection

There are two kinds of opportunity costs for gas injection:

1. Reducing gas consumption: a portion of domestic gas demand will not be covered;
2. Lowering export capability: reduce exports or delay export plans.

In this study we assumed that gas injection is not a limiting factor of gas consumption in domestic economy. Therefore we consider gas price in international market (average price during 1993-1997) as opportunity cost of gas injection:

Subject	Market	Average gas price (\$/MM Btu)
First scenario	World	2
Second scenario	United state	1.91
Third scenario	Europe	2.68

Three scenarios estimate the value of crude oil produced from secondary recovery activities. These are as follows:

Subject	Iranian light oil price (\$/bbl)
First scenario (1997)	18.24
Second scenario (1998)	12.03
Third scenario (1994-1998)	16.1

Three scenarios estimate income effects of natural gas substitution, the recovery after the oil fields change to gaseous fields, with liquid fuels. The structure of replaced energy consumption mix by natural gas in the whole country is as follows:

(%)

Fuel/Year	1997	1998	1994-1997
Kerosene	19.1	19.7	20.2
Gas oil	42.2	46.2	42.8
Fuel oil	32.5	27.1	30.9
LPG	6.2	7	6.1
Total	100	100	100

The value of its energy mix in different scenarios is as follows:

First scenario: 17.7 $/bbl
Second scenario: 12.4 $/bbl
Third scenario: 19.1 $/bbl

The formula of the netback index in the injection sector is defined as follows:

$$NPVB_t^{IJ} = S_{t=1} [(AOP_t^{IJ} + RGS_t^{IJ} - UPC_t^{IJ} - UPCR_t^{IJ} - OCG_t^{IJ} - REC_t^{IJ}) / (1+r)^t]$$
$$PVQ_t^{IJ} = S_{t=1} [Q_t^{IJ} / (1+r)^t]$$
$$NB_t^{IJ} = NPVB_t^{IJ} / PVQ_t^{IJ}$$

B_t^{IJ}: The benefits of natural gas injection to oil fields;
B_t^{IJ}: The net present value of the benefits in the injection sector;
AOP_t^{IJ}: The income of additional oil produced from secondary recovery activities;
RGS_t^{IJ}: The value of recovered gas substitution with other fuels;
UPC_t^{IJ}: The upstream costs of injected gas;
$UPCR_t^{IJ}$: The upstream costs of recovered gas from gaseous fields;
OCG_t^{IJ}: The opportunity cost of gas injection;
REC_t^{IJ}: The related costs of gas injection;
Q_t^{IJ}: The volume of injected gas;
PVQ_t^{IJ}: The present value of the volume of injected gas;
NB_t^{IJ}: The netback index in the injection sector.

Export

Most of the gas reserves of Iran are in southern regions of country. Therefore the netback index in the export sector is estimated by the assumptions that follow:

- Export of gas from the south (e.g. pars field) to the north (e.g. to Turkey);
- Construction of 1700 km high pressure pipeline;
- Volume of exported gas is 10 bcm/y;

The cost of gas exports consists of upstream (exploration and production) and downstream (refining and transmission) costs. The income of gas exports is estimated based on gas prices in the international market (average price during 1993-1997), mentioned in the three scenarios from the injection sector section. The value of natural gas substitution with other liquid fuels is considered the opportunity cost of exported gas. The structure and the value of the energy consumption mix can replace by exported natural gas in whole of country are mentioned in injection part. The formula of the netback index in the export sector is as follows:

$$NPVB_t^{EX} = S_{t=1} [(IGE_t^{EX} - CMG_t^{EX} - OCG_t^{EX}) / (1+r)^{t}]$$

$$PVQ_t^{EX} = S_{t=1} [Q_t^{EX} / (1+r)^{t}]$$

$$NB_t^{EX} = NPVB_t^{EX} / PVQ_t^{EX}$$

B_t^{EX}: The benefits of natural gas exports;
B_t^{EX}: The net present value of the natural gas benefits in the exporting sector;
IGE_t^{EX}: Income from natural gas exports;
CMG_t^{EX}: The cost mix of exported gas;
OCG_t^{EX}: The opportunity costs of exported natural gas;
Q_t^{EX}: The volume of exported gas;
PVQ_t^{EX}: The present value of the volume of exported gas;
NB_t^{EX}: The netback index in the export sector.

Example: Netback, DRC and RCR in industry sector

Hourly peak consumption and annual average consumption in industry sector:

Subject	Hourly peak consumption cm/h	Average consumption MMcm/y
First Case	500	2.19
Second case	1200	6.83
Third case	2000	14.54

Natural gas netback index in industry sector
Without taking into account opportunity cost

Subject	First case		
	Scenario 1	Scenario 2	Scenario 3
Present value of subscription, connection fee..(M$)	50.2	63.7	63.7
Present value of total CAPEX and OPEX (M$)	60.8	66.3	66.3
Total present value of costs for switching industries to gas (M$)	111	130	130
Present value of gas substitution income (M$)	2945.6	2105.6	3205.9
Present value of net gas substitution income (M$)	2834.6	1975.6	3075.8
Present value of gas consumption (MMcm)	29.8	29.8	29.8
Netback index ($/cm)	0.095	0.066	0.103
Subject	Second case		
	Scenario 1	Scenario 2	Scenario 3
Present value of subscription, connection fee..(M$)	120.5	152.8	152.8
Present value of total CAPEX and OPEX (M$)	145.9	159.2	159.2
Total present value of costs for switching industries to gas (M$)	266.4	312	312
Present value of gas substitution income (M$)	9190.3	6569.6	10002.3
Present value of net gas substitution income (M$)	8923.9	6257.5	9690.2
Present value of gas consumption (MMcm)	92.9	92.9	92.9
Netback index ($/cm)	0.096	0.067	0.104
Subject	Third case		
	Scenario 1	Scenario 2	Scenario 3
Present value of subscription, connection fee..(M$)	200.8	254.7	254.7
Present value of total CAPEX and OPEX (M$)	243.2	265.3	265.3
Total present value of costs for switching industries to gas (M$)	444.1	520	520
Present value of gas substitution income (M$)	19558.9	13981.4	21286.8
Present value of net gas substitution income (M$)	19114.8	13461.3	20766.8
Present value of gas consumption (MMcm)	197.6	197.6	197.6
Netback index ($/cm)	0.097	0.068	0.105

Subject	Average of cases			Total Average
	Scenario 1	Scenario 2	Scenario 3	
Netback index ($/cm)	0.096	0.067	0.104	0.089

Natural gas DRC and RCR indexes in industry sector
Without taking into account opportunity cost

Subject	First case		
	Scenario 1	Scenario 2	Scenario 3
Present value of gas subsitution income (M$)	2945.6	2105.6	3205.9
Present value of total foreign currency (M$)	76.86	87.61	87.61
Net present value of gas substitution income (M$)	2868.76	2018.01	3118.24
Net present value of local currency (MMRls)	102.47	127.19	127.19
DRC (Rls / $)	35.72	63.03	40.79
RCR	0.004	0.008	0.005
Subject	Second case		
	Scenario 1	Scenario 2	Scenario 3
Present value of gas substitution income (M$)	9190.3	6569.6	10002.3
Present value of total foreign currency (M$)	184.47	210.27	210.27
Net present value of gas substitution income (M$)	9005.87	6359.28	9791.98
Net present value of local currency (MMRls)	245.92	305.26	305.26
DRC (Rls / $)	27.31	48	31.17
RCR	0.003	0.006	0.004
Subject	Third case		
	Scenario 1	Scenario 2	Scenario 3
Present value of gas substitution income (M$)	19558.9	13981.4	21286.8
Present value of total foreign currency (M$)	307.45	350.45	350.45
Net present value of gas substitution income (M$)	19251.47	13630.90	20936.39
Net present value of local currency (MMRls)	409.87	508.77	508.77
DRC (Rls / $)	21.29	37.32	24.30
RCR	0.003	0.005	0.003

Subject	Average of cases			Total Average
	Scenario 1	Scenario 2	Scenario 3	
DRC (Rls / $)	28.11	49.45	32.09	36.55
RCR	0.004	0.006	0.004	0.005

Table1 Average of DRC and RCR indices of gas in Iran Without taking into account opportunity cost

	Rls/$	Rls/$	
Sectors	DRC Index	Average of DRC	Index RCR
Injection	43.16	390.7	.049
Export	453.86		
First type basket gas	674.98		

Table2 Average of Net back index of gas in Iran Without taking into account opportunity cost

Sectors	Scenario 1	Scenario 2	Scenario 3	Average of Scenarios	Priority
Injection	.132	.081	.120	.111	1
Export	.033	.030	.058	.040	5
Residential/ commercial	.089	.027	.067	.061	4
Power plant	.090	.066	.097	.085	3
Industry	.096	.067	.104	.089	2

Table 3 Average of Net back index of gas in Rian Taking into account opportunity cost

Sectors	Scenario 1	Scenario 2	Scenario 3	Average of Scenarios	Priority
Injection	.091	.040	.079	.070	1
Export	-.094	-.104	-.059	-.086	5
Residential/ commercial	.063	.001	.041	.035	4
Power plant	.065	.040	.072	.059	3
Industry	.070	.042	.079	.064	2

Fig1: Natural gas consumption in Iran (1985-2004)

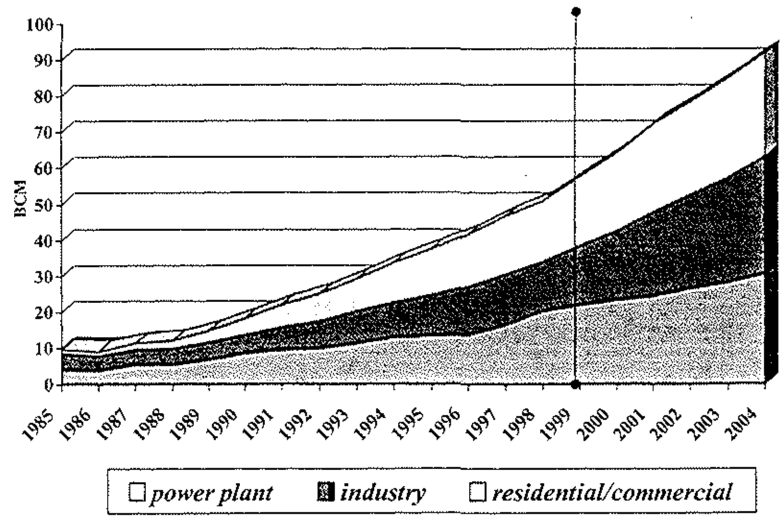

Fig2: Break down of natural gas consumption in Iran (in 1999)

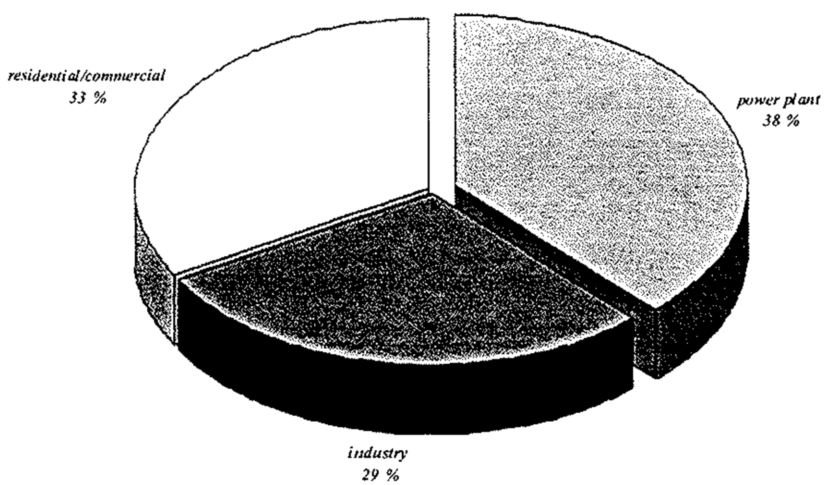

Fig3: Break down of Natural gas consumption in Iran (in 2004-end of third five-year plan)