Environment Canada - Global Air Issues Branch

COMPARATIVE ANALYSIS OF EMPLOYMENT FROM AIR EMISSION REDUCTION MEASURES

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Contents

EXECUTIVE SUMMARY

The objectives of this review are:

- to summarize existing information regarding the employment creation benefits of various energy efficiency and renewable energy actions that contribute to greenhouse gas reductions and air quality improvements; and

- to provide an initial comparison of the relative employment intensities of selected energy sector activities that have varying environmental impacts.

Over 30 studies and research reports of job creation from energy-related economic activities were reviewed and analyzed. While employment intensity estimates varied considerably based on input assumptions and methodologies, some very clear patterns emerged on which conclusions can be confidently drawn about the relative job creation potential of various types of energy activities.

On average, energy efficiency investments (e.g. building retrofits) create over 35 person years of employment per million dollars invested. This is about four times as many jobs as average levels for equivalent investments in energy supply: three times as many as alternative energy supply (e.g. solar, biomass) and five times as many as conventional energy supply (e.g. oil, gas).

One factor in the higher number of jobs per dollar invested in energy efficiency is that the activities tend to be fairly labour-intensive in terms of direct employment. The most important factor, however, is the job creation arising from the re-spending effect of energy savings.

Investments in energy efficiency are characterized by being:

- small and incremental in nature;
- geographically spread across the country;
- active in existing communities and commercial areas; and
- undertaken gradually over time.

This translates into employment characterized by its broad regional distribution, ongoing nature, and low to modest requirements for employee relocation.

Dollar for dollar, energy supply investments tend to yield one-third of the number of jobs arising from general expenditures in the economy; the latter are slightly less than energy efficiency expenditures in terms of their employment effects. However, there are significant differences within types of energy supply.

At an average of seven jobs per million dollars of capital and operating investment, the employment from various conventional supply options (hydro, oil, gas, coal, nuclear) tends to be low in relation to other energy and non-energy options. Among conventional energy supply options, oil sands offer the highest job creation potential at about 15 person years per million dollars of investment. Much of the employment generated by

mega-projects is in the short term initial construction phase, and so involves temporary employment of relocated workers. Smaller scale local energy supply options offer moderate levels of design and installation employment that is more incremental and regionally dispersed.

Investments in lower emission/renewable energy supply projects yields on average 12 jobs per million dollars. Wide variations were observed between study results, depending on the type of project and how much of the upstream feedstock production and equipment manufacture was assumed to be included. For any options, the job creation figures will increase if technology development and manufacture of equipment and components are conducted in the region or country.

In the transportation sector, vehicle efficiency measures, vehicle inspection maintenance programs, transit, and fuel substitution technology development hold promise for increased job creation, based on pilot-scale employment results.

Overall, investment in energy-related measures that will reduce air emissions including greenhouse gases will produce substantially higher levels of jobs created than if equivalent investments were made in conventional energy supply. Much private sector investment in energy efficiency activity and renewable energy technologies can be levered from moderate government investment, such as on a 6:1 basis. Opportunities lie in leveling the playing field between competing energy investments, in terms of income tax provisions, and in initiating and enhancing federal programs. Eight such measures were considered in this review. Depending on the measures and their design, uptake and investment, job creation could extend from 10,000 to 300,000 person years.

Where energy investments are being encouraged or leveraged by government policy on the basis of economic development and job creation, it is vital to have solid information on the labour intensity of various supply and demand options and ensure that any preferential treatment or policy support advantages the investments with the greatest relative job creation ability. The results gathered in this report provide an indication of the potentially significant employment benefits of various investments that would serve to reduce air emissions including greenhouse gases.

In the case of greenhouse gas reduction measures from energy efficiency and renewable energy investment, the federal government can advance regional air quality protection goals and international climate change commitments while supporting an energy development strategy that creates significant numbers of new jobs on a net basis.

It is recommended that federal energy-related economic development options be compared consistently for environmental and employment costs and benefits, and that a number of greenhouse gas reduction measures be implemented as part of the federal job creation strategy.

OBJECTIVES AND SCOPE

The primary objective of this review is to summarize existing information regarding the employment creation benefits of various energy efficiency and renewable energy actions that contribute to greenhouse gas reductions and air quality improvements. The secondary objective is to provide an initial comparison of the relative employment intensities of selected energy sector activities that have varying environmental impacts. As a point of comparison, the review includes some readily available employment figures for other sectors.

The scope of the review is limited to bringing together existing North American information, from the past decade, in a manner that facilitates comparison. The scope does not include comparing the relative greenhouse gas or air emissions profiles of various forms of energy efficiency or supply, although employment generation per unit of energy saved or produced is provided where readily available.

METHODOLOGICAL ISSUES

A description of the methodology used in this review is found in Appendix A. The reference list of documents is in Appendix B, and the list of contacts from whom information was received is in Appendix C.

Some thirty studies from across North America for the past decade were gathered and reviewed. Reasonably good data is available for the categories of measures and sectors listed in Appendix A. However, there were few nationwide studies for Canada that looked into employment intensities of various forms of energy supply nor energy efficiency programs. One study provides employment generation from a variety of greenhouse gas reduction measures, but does not disaggregate between types of measures.[1] There were several nationwide studies available for the United States on energy efficiency and climate change measures. Most of the studies collected related to specific regions or specific energy projects (both supply-side and demand-side).

Types of activities for which measure-specific data was not as readily or widely available were:

- transportation programs, including demand management, modal shifts, and fuel switching;
- manufacture and installation of renewable energy equipment in buildings (such as for heating and cooling);
- industrial energy efficiency measures;
- solar energy supply;
- production of renewable fuels (biofuels); and
- agricultural activities.

Studies provided some or all of the following types of data:

- total number of jobs, usually over a period of 5-20 years;

[1] Comeau, Louise. *Rational Energy Program.* Climate Action Network and Sierra Club, September ,1996. Analysis conducted by Informetrica and assisted by Natural Resources Canada.

- investment in the measures (generally a blended figure of capital and operating investment, though at times separating capital and operating investment on the supply side);
- jobs per million dollars spent; and/or
- energy saved or produced (in megawatt hours, megawatts of capacity, or dollars).

Many studies used the term "jobs" to refer to "person years of employment". Some generated a "jobs per million" (JPM) of investment dollars; others provided enough information that JPM calculations could be made. A small number of studies also estimated jobs per unit of energy saved or produced. This is an important ratio to consider alongside the jobs per dollar, because it is useful to see what the activity is yielding in terms of its energy savings or production (and therefore emissions). It can also be valuable to consider the absolute numbers of potential or actual jobs, which were almost always provided.

The methodologies reviewed:

- made use of existing input-output models to generate the expected impacts in various sectors of the economy resulting from an "exogenous impact" such as increased investment in certain activities;[2]
- gathered and summarized data from existing studies;
- used data or multipliers from existing studies to apply to particular scenarios and estimate results;[3] or
- tracked and reported actual employment, usually direct construction and operating employment, from particular projects or in particular sectors (sometimes applying a multiplier to yield expected indirect employment effects).

Generally, the methodologies appeared sound. This is primarily because government input-output models using official statistics (i.e. from Statistics Canada or its equivalent in the U.S.) were used to generate results. One problem with such models, however, is that the re-spending effect (i.e. from energy savings) may not be estimated as accurately as other effects. Some studies modify the input-output analysis to minimize this problem. Another drawback of such models is that they use old relationships between economic sectors, even if updated with more current figures. This becomes a problem if the structure and interrelationships between economic sectors changes a fair amount over the years, because the model is then less representative of the actual flows and effects of expenditures within the economy. Nonetheless, the use of such models provides the most thorough and reliable results.

[2] Input-output analyzes make use of models of the economy, whether regional or national, that contain linkages between sectors and how a dollar spent in one sector filters through to create effects in other sectors. I-O models implicitly include indirect and induced effects, and representative multipliers are sometimes calculated as a result, but results do not tend to be separated between direct, indirect, induced, re-spending or displacement effects. The latter refers to jobs lost in some sectors due to activity in others.

[3] Multipliers are factors that are used to estimate the indirect and/or induced effects on Gross Domestic Product (GDP), labour income and/or employment resulting from changes in the direct effects. Employment multipliers are generally expressed as the ratio of total jobs created in the economy to the direct jobs created, e.g. 2:1.

Some studies used multipliers, derived from sources available at the time, to estimate indirect employment. It appears that most used multipliers appropriate for the region under analysis. However, one problem is using old multipliers, or using current ones to extrapolate well into the future, when they may not apply. Given that most of the employment impacts from any of these options (whether supply-side or demand-side) are indirect, induced or re-spending (as opposed to direct), the explicit multipliers (or implicit ones in an input-output model) play a large part in calculating the total job benefits of a particular economic development measure.

It should be noted that there are a number of factors that make it difficult to compare the results of one existing study to another. These include differences in:

- the country and region for which the energy option is being analyzed (with implications for dollar values, multiplier effects, and leakages from regional economies);
- the types of projects and the extent to which upstream activities are included (such as manufacture of equipment and components, production of feedstock);
- whether direct, indirect, induced, re-spending and/or displacement effects are included;[4]
- assumptions regarding multiplier effects;
- the years of analysis, with associated dollar values and relative energy prices; and
- whether initial construction and/or ongoing operating investment and jobs are analyzed.

One difficulty encountered was discerning between direct, indirect, induced, re-spending and or displaced employment. While many provided gross employment and some others presented direct employment, few showed the breakdown between direct, indirect and induced (with the associated multipliers). Some studies included the re-spending and displacement effects, either separately or implicitly within an input-output analysis.

While the scope and timeframe of this study did not permit recognition of and adjustment for all these factors, some steps were taken to make results more comparable. These steps were:

- comparing studies that included direct, indirect, induced and re-spending effects;
- adjusting to remove the displacement effect where appropriate to bring estimates from net to gross employment for comparing options;
- applying a standard multiplier to a small number of studies for which only direct employment was provided;
- adjusting for the U.S.-Canada exchange rate and inflation rates over the years;

[4] Direct employment relates to the activity itself, such as conducting home energy retrofits. Indirect employment arises from suppliers of products and services to the direct activities, such as insulation manufacturing. Induced employment is generated when direct and indirect employees spend their wages, such as at restaurants and stores. The total of direct, indirect, and induced is generally termed gross employment. Respending employment occurs when money saved from taking measures such as energy-saving retrofits is re-spent on goods and services (as an increment to disposable income). The displacement effect refers to employment displaced, such as from the energy supply sector. Gross employment plus re-spending less displacement is referred to as net employment.

- relating results as jobs (expressed in person years) per million dollars invested (by the private and public sectors combined, for both capital and operating costs), or if possible per Megawatt of energy produced or saved;
- cumulating job estimates over the same time periods;
- generating averages of estimates in general categories, such as energy efficiency and energy supply; and
- providing employment figures for general expenditures in the economy as points of comparison.

It is worthwhile to note that studies that are nationwide or that apply to economically diverse regions should arrive at higher figures of employment per dollar invested, because more of the indirect employment effects are captured. Despite the variability and the difficulties in drawing direct comparisons, important general findings and clear trends within and between sectors become apparent.

ANALYSIS OF RESULTS

Introduction

This section summarizes our analysis of the studies' results. Tables of comparative employment estimates per million dollars of investment are provided in Appendix D. All but Table 5 are referred to below. Table 5 provides estimates for other sectors of the economy as points of comparison. Selected quotes and key findings from various studies are highlighted in Appendix E. In the discussion below, key findings from the tables are brought forth. Other findings are presented that are of interest but were not in a format suitable for adjustment and inclusion in the comparative tables. Conclusions regarding overall comparisons between sectors are provided in the Conclusions and Recommendations section.

Energy Efficiency/Conservation

After adjusting for exchange rates and inflation, the jobs per million dollars (JPM) for investments in energy efficiency and conservation ranged from 15.9 to 79.8, with many results in the 20 to 40 range, and an overall average of 36.6. (Table 1 in Appendix D). The variability in results relates primarily to what types of projects were being considered, differing estimates of the re-spending effect, whether the study was estimating regional or national results, and which regions were being analyzed.

Employment in energy efficiency and conservation takes place right in communities and areas of commerce and industry. Therefore, local labour can be employed and relocation is not necessary. Also, a large portion of the economic benefits accrue to the local area, and energy efficiency investments are made in all regions of the country. The jobs require varying degrees of skill, and are ongoing. Small incremental investments are adequate to get projects started and maintained.

Results of Studies

There were few nationwide studies for Canada. One of the few was a feasibility study for possible energy initiatives to by undertaken by Canadian municipalities; calculations

based on the figures provided result in 65.8 JPM.[5] For the U.S., estimates for nationwide job creation from efficiency and conservation measures ranged from 19.7 to 35.5 JPM.

A study of electricity options in Saskatchewan[6] compared a variety of demand and supply side options. The results for residential, commercial and industrial energy efficiency were higher than those of 18 energy supply options. The efficiency/ conservation measures also compared favourably among options in terms of employment per megawatt (MW) of capacity: the biomass options ranked highest with a result of 5.0 jobs per MW, followed by nuclear at 3.2, wind at 3.0, and conservation at 2.2.

In addition to reporting on other studies, the Marbek study[7] compared a traditional supply scenario with a demand-side efficiency scenario (to save as much power as would have been produced) for British Columbia. The efficiency scenario resulted in approximately twice as many jobs (an average of 35,250 for efficiency versus an average of 19,000 for supply).

The Federation of Canadian Municipalities (FCM) project that an investment of $1.9 billion in capital projects would yield about $200 million in energy savings and related employment would be as high as 130,000 person years[8]. (This translates into 68.4 JPM as mentioned above.).

A detailed analysis of the Ontario Municipal Energy Improvement Facility (OMEIF) estimates a total of 24-30 person years of direct, indirect and induced employment per $1 million in energy management expenditures, within the timeframe of the initiative. One example within the analysis estimates that a further 70.9 person years would be created, over the 15 year life of sample retrofit measures, from the re-deployment of energy savings arising from each million dollars of initial retrofit investment.[9] (At an average of 27 gross employment plus 71 re-spending, the total would be 98 person years per $1 million. In order to be conservative, we selected the national FCM figure for inclusion in Table 1).

The 1992 study by the American Council for an Energy Efficient Economy, which compares the employment effects of extensive improvements in all sectors of the economy with a business-as-usual scenario, concluded that about 293,000 new jobs could be created by 1995, 471,000 new jobs by 2000, and nearly 1.1 million jobs in 2010 on a net basis.

Based on studies that made adequate information available, direct jobs account for 25-40 percent of the total jobs generated by investments in energy efficiency. Information was not available to split energy efficiency jobs between capital and operating expenditures.

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[5] Federation of Canadian Municipalities. *Feasibility Study for the Federation of Canadian Municipalities - the Municipal Energy Efficiency Initiative.* August 1994.

[6] Saskatchewan Energy Conservation and Development Authority, *Evaluation and Recommendations For Saskatchewan's Electric Options 2003 to 2020*, July 1994.

[7] Ibid.

[8] Federation of Canadian Municipalities. *Feasibility Study for the Federation of Canadian Municipalities - the Municipal Energy Efficiency Initiative.* August 1994.

[9] Cummings, Rob. *Ontario Municipal Energy Improvement Facility (OMEIF): Partnerships for Jobs and the Environment - Business Plan.* International Council for Local Environmental Initiatives, 1994.

Climate Change Programs

Programs to reduce greenhouse gas emissions include energy efficiency, conservation, and renewable energy supply measures. Such measures may be applied in the residential, commercial, industrial, transportation, agricultural and non-energy sectors.

Informetrica estimated employment generation for the Rational Energy Program[10], which builds on a set of measures developed during the preparation of Canada's National Action Program on Climate Change. Cumulative gross employment is estimated to amount to two million person years by 2010. Given a cumulative investment on the part of the private sector of $32.9 billion and the government of $9.3 billion over that timeframe, it works out to 47.4 jobs per $ 1 million. (Note: after taking into account the displacement effects on the energy and other sectors, the net cumulative employment is estimated to be over 1.5 million person years.)

A 1994 study by the American Council for an Energy Efficient Economy[11] estimated the impacts of implementing the U.S. Climate Change Action Plan, in terms of energy savings, emissions reduction, gross domestic product (GDP), labour income, and jobs. The report states: "The overall economy is ahead by nearly 157,000 jobs (by the year 2000) as a result of the energy efficiency investments made in the climate action plan. For every job lost under the climate plan, about five jobs are created...by 2010, the economy has a net gain of nearly 260,000 jobs." The report goes on to say that if further cost-effective energy efficiency improvements were widely adopted throughout the economy (beyond those in the climate action plan), nearly 500,000 additional jobs could have been created by the year 2000.

A recent study estimated the impact on the Canadian oil and gas industry of imposing a carbon tax sufficient to reach targeted greenhouse gas emission reductions. The base case shows 67,000 direct employees in the oil and gas industry, staying constant from 1995 to 2005. The study estimates that to achieve stabilization of carbon emissions at 1990 levels by 2005 would result in a 10% or 7,000 job loss in the industry. The study further estimates that to achieve a 20% reduction below 1990 levels by 2005 would result in a 20% decline in jobs in the industry, or 16,100 employees. This number of jobs is not extensive in relation to the gains in the rest of the economy; such displacement is already taken into account in arriving at the net gain of 1.5 million jobs in the Rational Energy Program.

Transportation measures may fall under a number of the categories in this section; a brief discussion of available information is provided here. Preliminary findings from the B.C. input-output table suggest that consumer expenditures on transit provide about three times the employment as automobile expenditures.[12] AirCare, the vehicle inspection/maintenance program implemented in B.C.'s lower mainland, is estimated to have generated almost 500 new jobs (roughly half in contracted inspection and half in the repair industry). The American Council for an Energy Efficient Economy analyzed a vehicle efficiency scenario, which involved a gradual increase to 50 miles per gallon. By

[10] Comeau, Louise. *Rational Energy Program.* Climate Action Network and Sierra Club, September ,1996.
[11] Skip Laitner, *The Climate Change Action Plan as an Economic Development Strategy for the United States.* Washington DC: American Council for an Energy-Efficient Economy, May, 1994.
[12] Horne, Garry. *Economic Impacts and Performance.* B.C. Treasury Board, April 1996.

the year 2010, net job gains (already having deducted displacement effects) were estimated to be 244,000.

Alternative Energy Supply

Refer to the results presented in Table 2 of Appendix D. Estimates vary widely depending on the type of technology and location, but average out to 12.2. JPM.

Employment in alternative energy supply relates to construction of facilities and operation of technical capital equipment. Unlike conventional supply, the facilities tend to be smaller and located closer to communities. With respect to biomass, there is a strong component of ongoing labour in producing the feedstock. Moderate investments are adequate to get projects and the associated employment going.

Biomass

The Saskatchewan study[13] cited above provides the most comprehensive comparison of energy options. After the three energy efficiency/conservation options that ranked highest in employment generation per $1million investment, the next highest electricity supply options are the three biomass options reviewed in the study (using crop residue and logging residue as fuel sources). The jobs per million averaged 13.5; a fair amount lower than the demand-side options, yet still higher than all other supply options. On the basis of employment per MW produced or saved, the biomass options were substantially higher than all other options in the study. They were the highest, or among the highest, of supply options in terms of employment from capital expenditures as well as operating expenditures (whether calculated per MW of capacity or per $ million of expenditure).

An Iowa study[14] estimated the employment from their biomass option to be 59.4 JPM. This is for operations only; the estimate assumes using existing generation capacity.

Biofuels

Figures from NRCan (when it was formerly known as EMR) estimated that a 10% ethanol blend of fuel nationwide, assuming domestic production of the ethanol component, would generate approximately 63,500 one-time construction person years and over 39,000 operating person years annually.[15]

An ethanol plant that is being constructed in southern Ontario will involve over $150 million in plant construction and the following annual operating expenditures: $53 million corn purchases, $14 million supplies and services, and $2.5 million payroll. These expenditures generate economic activity in other sectors. The construction will create 400 person years of construction labour, and an additional 400 full-time direct and indirect jobs will be created (including 90 direct plant jobs and 40 direct operating positions). The construction of a $50 million ethanol plant, also in southern Ontario, will create over

[13] Saskatchewan Energy Conservation and Development Authority, *Evaluation and Recommendations For Saskatchewan's Electric Options 2003 to 2020*, July 1994.
[14] Weisbrod, Glen and Hagler Bailly Consulting Inc. et al*. Final Report: The Economic Impact of Energy Efficiency Programs and Renewable Power For Iowa*, December, 1995.
[15] As referred to in: *Agro Energy - the Economics and Future.* (source, date not provided*)*

260,000 work-hours of employment, or about 130 full-time jobs for one year.[16] These figures work out to 2.7 direct construction JPM and 5.8 operating, for a blended rate of 3.6 direct JPM. Applying a multiplier of 2.0 yields 7.2 direct, indirect and induced jobs per million.

Wind

Unlike other sectors, it is easier to get figures for jobs per MW or MWh for wind power than per dollar of investment. Jobs in manufacturing wind generation components are estimated to be about eight direct jobs/MW/year and 28 direct, indirect and induced jobs/MW/year.[17]

The American Wind Energy Association completed a comprehensive employment survey of California wind plant operators and their service providers, finding that there are 460 direct and 1500 indirect jobs per terawatt hour (TWh), for a total of 1,960/Twh/year.[18]

At 8.0 JPM, the labour intensity of wind energy was estimated in the Saskatchewan study to be in line with other alternative energy supply options presented in Table 2, and at 3.0 jobs per MW wind ranked third among Saskatchewan options behind biomass and nuclear. Wind ranked first for the employment impact per MW of capacity, arising from capital expenditures.

Solar

A 1995 press release from the Solar Energy Industry Association states that the companies in the U.S. solar industries directly employ nearly 20,000 people and support over 150,000 jobs in diverse areas such as glass and steel manufacturing, electrical and plumbing contracting, architecture and system design, battery and electrical equipment development, as well as solar equipment manufacturing.

Based on preliminary estimates, implementing tax incentives for increasing the solar energy markets in Canada may yield on average about 18 jobs per million dollars.

District Energy, Cogeneration, and Small Hydro

Estimates provided in Table 2 for these types of supply are 8.6 JPM for district energy in Canada, 9.5 JPM for cogeneration in Saskatchewan and 7.6 JPM for small hydro in Saskatchewan. Like conventional energy supply, these options are characterized by relatively greater construction jobs and fewer ongoing operating jobs. The Canadian District Energy Assocation estimates that 23 projects in Canada would yield 7,000 direct construction jobs and 2,500 ongoing operating jobs over a 20 year period.[19]

[16] from a press release provided from the Canadian Renewable Fuels Association.
[17] estimate from Paul Gipe, who wrote the study below.
[18] Gipe, Paul. *Overview of Wind Generation in North America and Europe.* Washington, DC: American Wind Energy Association, 1993.
[19] Canadian District Energy Association. *Energy Efficiency And Heating/Cooling From Renewable Energy Sources Consultations Process*. CDEA, September 30, 1996.

Conventional Energy Supply

Figures for conventional energy supply are provided in Table 3. Ranging from 2.6 for large hydro in B.C. to 14.9 for coal mining in the U.S., the average is 7.3 JPM. Individual types of conventional energy supply are not discussed under separate headings in this narrative, with the exception of oil sands, below.

Based on available information for employment over a period of 10 to 20 years, 10 to 20 percent of Alberta oil and gas jobs are direct. Of these, approximately 60 percent are related to capital expenditures and construction, and occur in the first four to five years. Of a package of Alberta oil and gas projects, ongoing gas operating jobs represent 20 percent of the total (construction and operating) jobs in the peak construction year, and ongoing oil operating jobs represent 35 percent of the total jobs in the peak construction year.

According to the Saskatchewan study, the jobs from capital expenditures among conventional energy supply options were highest for nuclear, coal and hydro-electricity; nuclear was highest in terms of jobs from operating expenditures. (Note from previously presented results of the Saskatchewan study that the employment from each of these conventional supply options was lower than each of the energy efficiency/conservation and biomass options.)

Employment in conventional energy supply tends to have a large component related to construction of the facility. Often these facilities are in fairly remote locations and temporary relocation is required for construction, permanent relocation for operation. The jobs require fairly highly skilled labour, due to the technical nature of the substantial capital equipment. There tends to be a long lead time before projects may proceed, and they proceed in large increments.

Oil Sands

While employment estimates for oil sands vary widely between sources and projects, at 14.6 JPM they are on average among the highest conventional energy supply job creators in Canada in terms of jobs per million dollars invested in construction and operation. In the first five years, construction-related employment is estimated to account for 94 percent of the total employment, dropping to 45 percent ten years later. Refer to Table 5 for a breakdown of various estimates of oil sands job creation potential. The estimates derived from figures presented by the Oil Sands Task Force are three to ten times higher than any of the other estimates.

Application to Potential Air Emission Reduction Measures

The results of the above analyzes, in terms of jobs per million, were applied to air emission reduction measures proposed by the Pembina Institute, among others, for federal implementation in Canada. These measures are designed to provide signals within the tax system and provide access to capital for investments in energy efficiency, heating and cooling from renewable energy sources, and the production of renewable fuels. Six measures are highlighted. Given the assumptions regarding uptake and investment outlined in the notes to Table 6 in Appendix D, the results extend from 10,000 jobs (person years) to 360,000 jobs per measure, as shown in Table 6.

CONCLUSIONS AND RECOMMENDATIONS

On average, the energy efficiency measures reviewed generate slightly more employment per unit of investment than general expenditures in the economy, 2.5 times that of Alberta oil sands, 3.0 times equivalent investments in alternative energy supply, and 5.0 times as much employment as investments in conventional energy supply. This is due in part to relative labour intensity of the activities, but a large factor is the employment effect arising from the re-spending of dollars saved from energy efficiency and conservation measures. Energy conservation also provides among the highest jobs per megawatt hour saved versus produced. The employment associated with these projects is more geographically spread out across the country and in communities, and tends to be more incremental and long term (rather than short term construction of large energy supply facilities).

The energy efficiency, conservation and renewable energy supply measures outlined in the Rational Energy Program are seen to yield over three times as many jobs on average as expansions to the Alberta oil sands.

Energy supply provides approximately one-third the number of jobs per dollar of investment than expenditures in the general economy.

On average, alternative energy supply provides over 1.5 times the jobs per dollar invested than conventional supply (e.g. large hydro, coal, oil and gas). There are exceptions to this general rule when comparing one particular option to another. However, generally speaking, alternative energy projects tend to be smaller scale and can be more labour intensive (such as in biomass options, and the installation of small scale solar systems).

Conventional energy supply tends to provide the lowest number of jobs per dollar invested. There are exceptions to this rule, as in the case of Alberta oil sands projects which yield more jobs per dollar than many other supply options (yet still less than half the jobs provided on average by equivalent investments in energy efficiency, conservation and climate change measures). Note: the average job creation estimate from oil sands includes the estimate by the Oil Sands Task Force, which was three to ten times higher than other available estimates.

This review has focused on total dollars invested in capital equipment and operating costs, combining the private and public investments. Two further points are worthy of note. First, the government portion of the investment tends to be by far the smaller amount; for example, energy efficiency programs sponsored by the government were seen to lever private sector funds on average on a 5:1 basis in the studies for which this information was noted. Secondly, the investment on the part of the government is compensated for in the form of increased tax revenues, and on the part of the private investors in terms of energy savings and profits. In the case of energy efficiency investments, the benefit to cost ratios are often in the order of 3:1.

It is recommended that:

1. a number of greenhouse gas reduction measures related to energy efficiency and renewable energy should be aggressively pursued as important positive contributors to the federal government's job creation strategy;

2. all energy-related economic development options being encouraged or supported by the federal government should be assessed relative to the range of options available in an objective, independent and consistent manner so that the combined environmental costs or benefits and employment costs and benefits can be compared;

3. the federal government job creation strategy should be more closely integrated with air quality protection and climate change strategies and action plans to ensure that multiple environmental and employment benefits are realized;

4. a nationwide study should be undertaken to compare various air emission reduction measures and other energy sector options in more breadth and depth in terms of:

    - the relative employment intensities,
    - employment characteristics (e.g. longevity and ability to address unemployment concerns),
    - eco-efficiency indicators, such as carbon dioxide emissions per employee, and
    - net cost/savings to government per job created.

5. findings from existing studies, in terms of positive impacts on GDP and other economic indicators of air emission reduction measures, should be brought forth and highlighted.

APPENDIX A: METHODOLOGY

Approach and Steps

1. Framing the Study

Representative greenhouse gas and other air emission reduction measures were first identified for analysis, given their general employment intensity, and the likelihood of available data.

Energy efficiency/conservation measures include:

- the construction and retrofitting of energy efficient buildings in the residential and commercial sectors;
- utility demand side management (DSM) programs;
- industrial energy efficiency improvements; and
- vehicle energy efficiency measures.

Renewable energy and energy efficiency supply measures include:

- electricity generation from wind, solar, small hydro and biomass;
- installation of active and passive solar equipment in buildings;
- production of renewable fuels, i.e. biofuels; and
- cogeneration and district energy.

Conventional energy supply modes, both renewable and non-renewable (and with differing air emission profiles) included for comparison are:

- electricity generation from conventional hydro;
- nuclear electricity generation;
- electricity generation from coal;
- oil and gas; and
- oil sands.

Other sectors, provided as points of comparison, include:

- construction and renovation;
- households;
- retail;
- commercial;
- industrial; and
- government.

2. Data Gathering and Review

Data from existing studies was gathered and reviewed, and the methodologies employed to estimate the amount of employment generated were identified and assessed. The review focused on material from the last ten years in Canada and the United States.

The study methodologies and general assumptions were reviewed to determine:

- whether they are geared to determine direct, indirect, induced and/or re-spending employment[20];
- what multipliers are used, if any; and
- what modeling techniques are employed, if any.

The methodologies were assessed for their characteristics, strengths and weaknesses. The results of various studies were collated for comparison.

3. Analysis and Adjustment

The reported results of various studies were analyzed and in some cases adjusted for greater comparability by:

- ensuring that direct, indirect, induced and re-spending jobs were being compared 'like with like';
- relating employment to a common denominator such as dollars invested, or energy produced/saved;
- adjusting dollar values from different years for inflation; and
- adjusting for exchange rates.

It was not possible to adjust for multipliers used in order to achieve a common footing in this regard. This was because many studies made use of input-output models in which multipliers are implicit but not explicit, and many studies were regional (for which other multipliers may not be relevant).[21]

It was possible to note major differences in assumptions, such as what type of energy supply project or building energy efficiency project was being analyzed. However, it was not possible to adjust for these differences that serve as the foundation of the studies.

Some of the data was extrapolated to a national level for illustrative purposes. This was done by taking figures, for example, of employment per million dollars invested in building energy efficiency, or jobs created by a particular energy efficiency project. These figures were multiplied to show the order of magnitude impacts of a program with a given national budget, or which covers a given percent of the national building stock. This was done primarily to illustrate the employment potential of proposed federal budget measures and programs. No econometric modeling was undertaken within the limited scope of this study.

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[20] Direct employment relates to the activity itself, such as conducting home energy retrofits. Indirect employment arises from suppliers of products and services to the direct activities, such as insulation manufacturing. Induced employment is generated when direct and indirect employees spend their wages, such as at restaurants and stores. Respending employment occurs when money saved from taking measures such as energy-saving retrofits is re-spent on goods and services (as an increment to disposable income).

[21] Multipliers are factors that are used to estimate the indirect and/or induced effects on Gross Domestic Product (GDP), labour income and/or employment resulting from changes in the direct effects. Employment multipliers are generally expressed as the ratio of total jobs created in the economy to the direct jobs created, e.g. 2:1. Input-output analyzes make use of models of the economy, whether regional or national, that contain linkages between sectors and how a dollar spent in one sector filters through to create effects in other sectors. I-O models implicitly include indirect and induced effects, and representative multipliers are sometimes calculated as a result, but results do not tend to be separated between direct, indirect, induced, re-spending or displacement effects. The latter refers to jobs lost in some sectors due to activity in others.

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27. Saskatchewan Energy Conservation and Development Authority. *Evaluation and Recommendations For Saskatchewan’s Electric Options 2003 to 2020*, July 1994.

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29. Weisbrod, Glen and Hagler Bailly Consulting Inc. et al*. Final Report: The Economic Impact of Energy Efficiency Programs and Renewable Power For Iowa*, December, 1995.

APPENDIX C: CONTACTS

Name	Organization	Phone Number
	Bank of Canada	613-782-7506
	Statistics Canada	416-973-6586
	Energy Efficiency & Renewable	515-732-3731
	Energy Clearing House	
Bell, Warren	BC Ministry of Energy, Mines & Petrol	604-952-0244
Chute, R.	Ont. Ministry of Energy & Environment	416-323-5936
Clarke, Matthew	Goodman Group (Boston)	617-330-1660
d'Angelo, Peter	Besto (ESCO)	416-5995132
Dalgleish, Laverne	National Energy Conservation Ass'n	204-783-1273
Edworthy, Jason	Nor'Wester Energy Systems Ltd.	403-289-4399
Goldberger, Dan	ICLEI	416-392-1462
Michael Manolson		
Henrickes, Derrick	BC Hydro	604-528-1441
Lacroix, Anik	Statistics Canada	613-951-1807
Martall, Janet	Ontario Assessment Board	416-484-7800
Martin, Pat	Manitoba Carpenters' Union	204-774-1609
Morris, Richard	City of Toronto	416-392-1452
Pastor, Marie Helene	CMHC	613-748-2314
Peters, Roger	Sask. Energy & Conservation	306-933-5310
publications - Judy	ACEEE	202-429-8873
Smith, Judy	Ralph Torrie & Associates	613-824-3045
Sonnen, Carl	Informetrica	613-238-4831
Stevens, Scott	Consumers Utilities, CDEA	905-508-3474
Stone, Monica	Iowa Dept. of Nat. Resources	515-281-6361
Westenbrook, Tony	CMHC	613-748-2819

APPENDIX D: EMPLOYMENT ESTIMATES PER UNIT OF INVESTMENT[22]

TABLE 1: ENERGY EFFICIENCY/CONSERVATION/CLIMATE CHANGE MEASURES		
Application	**Jobs per $M**	**Ref. No.**
Rational Energy Program for Canada	47.4	9
Saskatchewan Residential Energy Efficiency/Cons.	15.9	28
Saskatchewan Commercial Energy Efficiency/Cons.	20.7	28
Saskatchewan Industrial Energy Efficiency/Cons.[23]	79.8	28
Toronto Energy and Water Efficiency	42.9	7
Ontario Demand Side Management	38.5	13
B.C. Demand Side Management	30.6	17
Canadian Municipal Energy Initiative	65.8	6
U.S. Conservation	23.5	26
U.S. Energy Efficiency	32.5	22
U.S. Energy Efficiency	27.1	23
U.S. Energy Efficiency and Renewable Energy	35.5	25
U.S. Demand Side Management	19.7	18
Washington State Demand Side Management	31.8	18
Average	36.6	

TABLE 2: LOW-EMISSION/RENEWABLE ENERGY SUPPLY PROJECTS		
Application	**Jobs per $M**	**Ref. No.**
Saskatchewan Biomass Electricity Generation	13.5	28
Saskatchewan Wind Electricity Generation	8.0	28
Saskatchewan Small Hydro Electricity Generation	7.6	28
Saskatchewan Cogeneration	9.5	28
Canadian Solar Thermal	27.9	note[24]
Canadian Photovoltaics	8.2	note[25]
Canadian District Energy	8.6	5
Ontario Biofuels	7.2	note[26]
Iowa Biomass Electricity Generation[27]	29.7	30
Iowa Wind Electricity Generation	1.8	30
Average	12.2	

[22] Jobs per Million (JPM) in these tables refers to gross (direct, indirect and induced) plus re-spending person years per $ 1 million in capital and operating costs, in 1996 Canadian dollars. Multipliers of 2.0 were applied to direct employment figures for: Alberta oil and gas and one oil sands estimate, district energy, and biofuels. Reference numbers coincide with the numbered Reference List in Appendix B.

[23] The original figure provided in the source study was divided in half in order to be conservative about the dollar value of energy savings and the resultant re-spending effect.

[24] Derived from figures received from the Canadian Solar Industries Association.

[25] Derived from figures received from the Canadian Solar Industries Association.

[26] Derived from figures received from the Canadian Renewable Fuels Association.

[27] The original figure provided in the source study was for operating costs only, and so was divided in half to reflect the lower overall JPM when capital costs and person years are taken into account.

TABLE 3: CONVENTIONAL ENERGY SUPPLY PROJECTS		
Application	**Jobs per $M**	**Ref. No.**
Alberta Oil	6.5	21
Alberta Oil Sands	14.6	Table 4
Alberta Gas	4.0	21
Saskatchewan Oil Combined Cycle	4.1	28
Saskatchewan Natural Gas Electricity Generation	5.8	28
Alberta Large Hydro-Electric	1.4	21
Saskatchewan Large Hydro-Electric	8.2	28
B.C. Large Hydro-Electric	2.6	17
Saskatchewan Coal	9.3	28
Saskatchewan Nuclear	9.7	28
U.S. Oil Refining	6.1	23
U.S. Natural Gas	7.8	23
U.S. Coal Mining	14.9	23
Average	7.3	

TABLE 4 : ALBERTA OIL SANDS PROJECTS		
Application	**Jobs per $M**	**Ref. No.**
Oil Sands Task Force	36.6	16
Oil Sands Projects- Workforce Requirements	7.6	21
Suncor - Fixed Plant Expansion	13.4	note[28]
Suncor- Steepbank	3.8	note[29]
Suncor - Aurora (Train 1)	11.5	note[30]
Average	14.6	

TABLE 5: INVESTMENTS IN OTHER SECTORS		
Application	**JPM**	**Ref. No.**
Canada - Residential Renovation	34.2	8
Canada - New Residential	27.9	8
Canadian Retail	42.5	8
U.S. Retail	36.1	23
U.S. Households	23.0	22
U.S. Industrial	27.4	22
U.S. Government	24.9	22
Average	30.9	

[28] Suncor Inc. Oil Sands Group. *Application for Approval of the Fixed Plant Expansion Project.* March, 1996.
[29] Suncor Inc. Oil Sands Group. *Steepbank Mine Project Application.* March, 1996.
[30] Bovar Environmental. *Environmental Impact Assessment for the Syncrude Aurora Mine.* June, 1996.

TABLE 6: ILLUSTRATIVE PROPOSED TAX MEASURES[31]			
Measure	**Private Invest.[32]**	**JPM[33]**	**Jobs[34]**
1. Higher CCA Rate for Energy Efficient Buildings[35]	$ 250 million	36.6	9,150
2. Higher CCA Rate for District Energy[36]	$ 2.2 billion	8.6	18,900
3. Energy Audit Tax Credit[37]	$ 1 billion	36.6	36,600
4. RRSP Loan for Energy Efficient Homes[38]	$ 5 billion	36.6	183,000
5. Biofuels Flow-Through Shares[39]	$ 1.5 billion	7.2	10,800

TABLE 7: ILLUSTRATIVE PROPOSED PROGRAM MEASURES[40]			
Measure	**Private Invest.**	**JPM**	**Jobs**
6. Energy Efficiency Revolving Fund[41]	$ 200 million	36.6	7,320
7. Green Power Procurement[42]	$ 500 million	12.2	6,100
8. Expanded FBI, Energy Innovators, C-2000 Programs[43]	$ 200 million	36.6	7,320
9. National Vehicle Inspection-Maintenance Program[44]			3,000

[31] These measures were proposed and described by the Pembina Institute for the 1997/98 Federal Budget, in a submission dated Dec. 30, 1996.
[32] Private investment: does not include government investment in the form of tax revenues foregone, which would be much smaller but would depend on the rates set.
[33] Jobs per $1 million figures drawn from previous tables.
[34] Estimated total person years based on these calculations and assumptions.
[35] Refers to a higher Capital Cost Allowance rate for energy efficient commercial buildings, within the federal income tax system, with employment estimates if the measure induced $250 million private investment (1,000 buildings at $250,000 renovation each). The measure as proposed would also provide a higher CCA rate for heating and cooling from renewable energy sources.
[36] Refers to a higher Capital Cost Allowance rate for energy efficient commercial buildings, within the federal income tax system, with employment estimates if 23 likely projects were to proceed.
[37] Refers to a $150 tax credit for energy audits of homes and small businesses, with employment estimates for homes only, if 5% of the 10 million households spent $2000 on retrofits.
[38] Refers to a $10,000 loan from Registered Retirement Savings Plans for purchasing or upgrading to more energy efficient homes, with employment estimates for a 5% uptake.
[39] Refers to providing Flow-Through Shares to biofuels within the federal income tax system, with employment estimates if this induced the construction and operation of 10 ethanol plants.
[40] These measures were proposed within the Rational Energy Program and/or the Pembina Institute (and others') federal budget submissions for the 1997/98 budget.
[41] Refers to the provision of a revolving fund for energy efficiency investments in the residential, commercial and industrial sectors, with employment estimates if $200 million in loans were provided.
[42] Refers to federal procurement of green power, and encouragement of others to do the same, which would induce investment in green power facilities.
[43] Refers to expanding the Federal Buildings Initiative, Energy Innovators Program for industry, and the C-2000 energy efficient buildings program, which would induce private investment in these areas.
[44] Refers to a national program of vehicle inspections and maintenance that would be run along the lines of Vancouver's AirCare program. AirCare is estimated to have generated 500 new jobs to date, which applied to 6 cities (or more cities of lesser size) would yield 3,000 additional jobs.

APPENDIX E: CONCLUSIONS FROM SELECTED STUDIES

- "Energy efficiency shows an even more substantial advantage in both GDP and employment...each dollar of DSM expenditure is three times as effective in generating GDP and jobs as the equivalent expenditure on supply." [45]
- "Investing an amount equal to the cost of Great Whale in an expanded electricity efficiency program would, under conservative assumptions, produce 52% - 106% more employment in Quebec than the Great Whale project."[46]
- 4 to 5 times as many job-years would be generated in the state of Maine by a demand side management program than by construction and operation of a coal-fired generating station.[47]
- Investments in efficiency and renewables technology generated anywhere from two to ten times as many jobs in New York state for every million dollars invested as those in fossil fuels.[48]
- "In percentage terms, the studies indicate that between 50% and 500% more jobs are created through investment in DSM than through equivalent investment in new supply...The re-spending of the energy bill savings generates a magnitude of employment that eclipses the other employment effects. It is the relative magnitude of these re-spending effects, as well as the quality and distributional characteristics of the employment potential that they represent, that leads to the conclusion that electricity conservation investments offer a superior employment strategy as compared to equivalent investments in new supply." [49]
- "Dollar for dollar, investment in electricity conservation and DSM in Newfoundland would generate between two to four times as much employment as investment in the Lower Churchill megaproject, or 7-20 more jobs per million dollars of investment."[50]
- "Conserving energy reduces the energy bills paid by consumers and businesses, thereby enabling greater purchase of non-energy goods, equipment and services. The result is a shift of economic activity away from energy supply industries and towards sectors of the economy which employ more workers per dollar received."[51]
- "Energy efficiency improvements lead to more jobs and higher personal income at the national level, in addition to saving consumers money, reducing energy imports, and cutting pollutant emissions associated with energy supply...we can create more jobs and better protect the environment by adopting policies that enhance energy efficiency."[52]
- "For investments in the electricity sector, efficiency programs tend to produce similar, to moderately greater, numbers of direct and indirect jobs per kilowatt hour than do

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[45] Leonard S. Rodberg, "*Employment Impact of Alternative Energy Demand/Supply Options*", presented by the Coalition of Environmental Groups for a Sustainable Energy Future to the Ontario Environmental Assessment Board Ontario Hydro Demand/Supply Plan Hearings, December, 1992.
[46] Goodman, Ian et al. *Employment Effects of Electricity Provision in Quebec: The Great Whale Hydroelectric Project and Electricity Efficiency Alternative.* Boston: The Goodman Group, June 1992.
[47] A Comparison of the Employment Creation Effects of the AES-Harriman Cove Coal-Fired Generating Station and Maine Demand Side Management - 1991
[48] New York State Energy Plan, Economic Development Staff Report - May 1989
[49] Torrie Smith Associates. *Employment Impacts of Energy Efficiency: Literature Review and Implications to Newfoundland*, for the Innu Nation, June, 1993.
[50] Ibid.
[51] Geller, Howard, John DeCicco and Skip Laitner. *Energy Efficiency and Job Creation: The Employment and Income Benefits from Investing in Energy Conserving Technologies.* Washington DC: American Council for an Energy-Efficient Economy, October 1992.
[52] Ibid.

supply options. However, when studies compared the number of jobs created per million dollars of investment, most reported that efficiency investments provided 1.2 to 2 times as many direct, indirect and induced jobs as a similar level of investment in traditional energy supply options."[53]

- "At $108,000 capital investment per employee it takes about 21 times the amount of investment to create a job in the petroleum industry than it does to create one job in the apparel and textile industry. Jobs created by investments in public utilities are the second-most expensive, about $105,000 each." The same study provided results of a Bonneville Power Administration study that found that high impact conservation programs create more jobs than would be created by building new power plants to generate an equivalent amount of energy.[54]
- "Energy efficiency produces somewhat less employment per unit of energy supplied. On the other hand, it produces more employment per dollar of expenditure, and increases real incomes."[55]
- "Computations of the expected economic and employment impacts of energy programs indicate that, dollar for dollar, energy efficiency programs create many more jobs than supply alternatives." "These jobs are more widespread and contribute to the maintenance of more stable communities."[56]
- "Only the biomass and conservation options have the potential to generate more employment per dollar than general expenditures in the economy...On a per MW basis, the three biomass options create more than twice the additional employment compared to the conventional coal, natural gas, and oil options." (Note: this study showed biomass, nuclear, wind and conservation to yield the highest number of jobs per megawatt.)[57]
- Job years per megawatt are shown to be highest for conservation, solar and cogeneration.[58]
- "Several studies went so far as to conclude that, despite the obvious construction and operating jobs, investments in conventional energy supply may actually cause the economy to lose jobs. This is because once ratepayers begin to pay for the construction and operation of the new plant through increased energy costs, a larger portion of their spending is diverted to the energy sector and away from other sectors that use more labour."[59]

[53] Marbek Resource Consultants Ltd. and G.E. Bridges & Associates Inc. *Energy Investments and Employment.* The British Columbia Energy Council, August, 1993.
[54] Environmentalists for Full Employment. *Jobs and Energy.* Spring, 1977.
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[57] Saskatchewan Energy Conservation and Development Authority, *Recommendations for Saskatchewan's Electric Options - 2003 to 2030*, July, 1994.
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[59] Marbek Resource Consultants Ltd. and G.E. Bridges & Associates Inc. *Energy Investments and Employment.* The British Columbia Energy Council, August, 1993.