Transforming Saskatchewan's Electrical Future

PART FIVE

The Public Policies Needed to Build a Renewable Energy Society in Saskatchewan

By Peter Prebble

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July 2011

This paper is written as part of an ongoing project, Green Energy Project Saskatchewan. GEPS is a civil society group, established to develop a plan for the conversion of Saskatchewan's electricity grid to sustainable renewable options by the earliest possible date. Stemming both from concern for the welfare of the human species and from a respect for the earth and all of its natural systems, we seek the attainment of sustainability, as defined by the UN-sponsored Brundtland report in 1987: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Basic principles of compassion and justice demand that we move rapidly to phase out fossil fuel usage and therefore eliminate our largest contribution to global climate change. We owe this to all the potential victims of climate change, locally, nationally and globally, in our generation and in generations to come. We therefore seek options for energy provision which are based on the following principles:

- Efficient use of resources — achieving desired results with as little energy consumption as is realistically possible.
- Use of renewable options — i.e. the energy sources which will endure for as long as possible.
- Technical viability — both innovative and traditional choices, designed and assessed according to the best available scientific and technological methods available.
- Recognition and respect for the rights of indigenous people at home and low-income people worldwide in the choice of technologies and the way in which they are implemented.
- Minimization of negative environmental impacts and respect for ecosystems.
- Optimization of opportunities for local social and economic development.

More information on GEPS and sustainable energy practices can be found at our website: *http://greenenergysask.ca*

About the Author

Peter Prebble has been involved in Saskatchewan's environmental movement for 34 years. He holds a Master's Degree in Sustainable Environmental Management and a Master's Degree in Education. He also holds a Bachelor's Degree in Business Administration and was awarded a Governor General's Gold Medal upon completion of his undergraduate work. Peter was a Member of the Saskatchewan Legislature for 16 years. He held several Cabinet posts and served as the Premier's Legislative Secretary for Renewable Energy Development and Conservation. He has also worked in many roles for the Saskatchewan Environmental Society, most recently serving as their Director of Energy and Water Policy.

Printed copies: $10.00. Download free from the CCPA website.

ISBN 978-1-926888-42-2

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The Public Policies Needed to Build a Renewable Energy Society in Saskatchewan

Saskatchewan is blessed with a remarkable array of renewable energy resources for our population size. Southern Saskatchewan has one of the best wind resources in Canada and the best solar profile in the country. In northern Saskatchewan there are important opportunities to develop small scale, run of the river hydro. We are also fortunate to have a deep underground geothermal resource in many communities south of Regina and a valuable forest resource which can be used sustainably to produce wood chips for both electricity generation and space heating. Our forests and the waste products from agriculture also offer other opportunities for biomass development. Mark Bigland-Pritchard has eloquently discussed the technical potential of these resources in the third and fourth paper in this series.

To date, Saskatchewan has opted to rely on fossil fuels to meet most of our electricity and space heating needs. However, in the face of the serious consequences of climate change, the decades ahead must be a time for reducing our reliance on coal and natural gas, and moving instead to building a society that relies primarily on renewable sources of energy, while at the same time using energy more efficiently.

We should begin this conversion process right away for two reasons. First, it will take at least twenty five years to complete, if it is to be done in a carefully planned and cost effective manner. Second, the international scientific community is warning the world that all countries and regions must achieve deep greenhouse gas cuts over the next two decades if the most dangerous consequences of global climate change are to be avoided. A large number of climate scientists are of the view that the average greenhouse gas footprint in the world must be reduced to no more than two tonnes per capita by 2050 and preferably lower by the end of the century.[1] At present Saskatchewan's greenhouse gas footprint is 71 tonnes per capita and Canada's footprint is consistently over 20 tonnes per capita, so getting started promptly on concrete reductions is urgent.[2]

This paper lays out the policy changes needed to begin to make an orderly shift away from fossil fuels and towards renewable energy in order to meet our electricity and space heating needs in Saskatchewan. Any shift to renewable energy should have as its foundation the more efficient use of energy. This paper therefore explores the policies needed to put that foundation in place. While other papers in this series have focused solely on electricity generation, this paper expands the scope of discussion to space heating, recognizing that when designing public policy, the two topics are intimately connected together. ***The final segment of the paper updates the reader on the urgent nature of the global climate crisis and some of the Saskatchewan implications.*** The paper's footnotes provide the reader with both references and additional information on many of the topics under discussion.

1 Give SaskPower a new mandate that makes the provision of electricity efficiency services and renewable electricity a much larger part of its business

SaskPower is one of our most important Crown Corporations and has a strong record of customer service. However, depending on the year, between 55 percent and 62 percent of all the electricity supplied in Saskatchewan comes from coal — the worst polluting of the fossil fuels.[3]

Legislation should be adopted in the Saskatchewan Legislative Assembly changing SaskPower's mandate so as to give first priority to electricity efficiency as a source of energy and second priority to the adoption of renewable sources of electricity generation.[4] The Legislature should expressly prohibit the construction of additional coal fired power plants and should require all new electricity generation facilities to meet stringent greenhouse gas emission standards, thus making them low emission facilities. The Legislature should also give direction to facilitate the steady phase out of existing coal fired power plants, particularly in light of their contribution to climate change. Large expenditures that extend the lifetime of these plants beyond their intended time of closure should be avoided; rather the billions of dollars required for such lifetime extensions should be used instead to help build a renewable energy future for our province.

Such legislation would fundamentally change the direction of SaskPower and would be reflected in the preparation of all relevant Cabinet Decision Items, the budget allocation process and the electricity generation projects that are brought to Cabinet for approval. SaskPower would also be expected to make staffing decisions that reflect the new mandate.

2 Revise the mandate of SaskEnergy to provide an increased focus on energy efficiency and renewable energy installations for space and hot water heating

SaskEnergy currently sees itself as a natural gas company. However, for most Saskatchewan residents it is a valuable Crown Corporation that meets their space heating and hot water needs. In addition to natural gas, there are many potential opportunities to meet these needs through the application of renewable energy sources. SaskEnergy should be mandated to promote the installation of solar energy, biomass energy and geo-exchange either on individual buildings or at a neighbourhood scale and in all circumstances where a significant net reduction in greenhouse gas emissions can be achieved through the installation. It should also be mandated to make energy efficiency its highest priority, thus helping customers to achieve maximum energy, financial and greenhouse gas emission savings.

3 The implementation of building codes for energy efficiency

Saskatchewan has one of the coldest climates in the world and yet we have no standard that governs the energy efficiency of our newly constructed commercial and residential buildings. As a result, many newly constructed buildings are out of date from the standpoint of energy efficiency, from their very first month of operation. This results in a needless waste of natural gas and unnecessary additional utility expenses for building owners. It also results in greenhouse gas pollution that is readily preventable. The time has come for energy efficiency standards to become a central feature of the Saskatchewan Building Code. Ontario has an energy efficiency code for new homes and commercial businesses as does

all of Western Europe and most state governments in the U.S.A.

One logical starting point would be for Saskatchewan to move to adopt comparable energy efficiency standards to Ontario. In the residential sector, for example, Ontario will require by 2012 that all new home construction be done to the standard of Energy Star.[5] Such a move in Saskatchewan would represent a substantial improvement in energy efficiency over typical new home construction today.[6] At the same time, it is still an easily achievable standard that is consistent with the best use of conventional construction methods.

Another sensible option for Saskatchewan would be to require that all buildings be wired and oriented in such a way that they can make use of solar photovoltaic systems in the future. The price of solar photovoltaic systems is falling steadily and solar photovoltaic installations work well in cold climates. Future building design in Saskatchewan should be done in such a way as to give all our residents the option of easily installing a solar photovoltaic system, when the price becomes affordable.

4 Education and training in energy efficiency and renewable energy installation

Saskatchewan cannot achieve high levels of energy efficiency and renewable energy installation unless it has a trained workforce to do so. Specialized training will be needed within SaskPower and SaskEnergy and within the electrical, plumbing, carpentry and other construction related trades. For example, in the buildings and electricity sector, training will be needed in energy efficient retrofit, the siting and installation of renewable energy technologies, the enforcement of building code standards for energy efficiency, and the integration of solar power and wind power into the provincial grid.

SIAST and the University of Saskatchewan should be asked to lead this training initiative. Saskatchewan programming should aim to take training to a level that meets North American standards. For example, installers of renewable energy systems should be trained to the standards of the North American Board of Certified Energy Practitioners.[7] It is also important that the scale of training is large enough to ensure that Saskatchewan makes substantial progress in its transition to renewable energy over the next decade. Therefore, hundreds of appropriately trained personnel will be required.

Moving forward with renewable energy and energy conservation initiatives in Saskatchewan will create many exciting new opportunities for employment creation for those with the appropriate skills to undertake the work. Energy efficiency initiatives are particularly labour intensive, when compared to fossil fuel and nuclear power projects. Renewable energy installations also compare favourably, creating new jobs in the site assessment, construction, assembly, installation, maintenance and general operation of a wide array of wind, solar, geothermal, small scale hydro, biogas, landfill gas and other biomass projects.[8]

5 SIAST and Saskatchewan's universities should become leading edge examples of the transition to a renewable energy economy

The University of Saskatchewan, the University of Regina and SIAST should be invited by the Provincial Government to enter into a partnership that would see them meet a very high percentage of their own energy needs from renewable sources by 2020. If we are to succeed in our transition to a renewable energy society, our post-secondary institutions should be funded to help lead the way and should be invited to contribute important technical expertise in meeting mutually agreed upon, ambitious targets for energy savings and renewable energy generation.

For instance, SIAST campuses, with their plumbing, heating, electrical and mechanical engineering programs on site, would be excellent locations to install solar hot water and solar photovoltaic systems. SIAST students, where applicable, could be trained in the installation, monitoring and maintenance of these systems, which would be modeled for the entire community. In addition, SIAST carpentry students could be involved in a process to retrofit campus buildings to much higher levels of energy efficiency. A growing number of post-secondary institutions in North America are working to 'green' their campuses and in some cases to become 'carbon neutral', so Saskatchewan's universities and SIAST campuses will have many partners to work with.[9]

6 Promotion and display of practical, super-energy efficient building design

The Provincial Government, in conjunction with Saskatchewan home builders and urban municipalities, should finance the costs of constructing and publicly displaying for at least a year one super-energy efficient house in every city in our province. These homes would be built to energy efficiency levels far in excess of the proposed Energy Star building code. In many cases the homes would approach carbon neutral status. The public should be encouraged to tour these homes and local builders should be actively involved in their construction. The purpose of the initiative would be threefold: public education, an opportunity for the local construction industry to learn now to build to a much higher level of energy efficiency and an attempt to permanently shift building practice and home buyer preference in Saskatchewan.

An example of what can now be built in a cost effective way is provided by the Holzkaemper residence in Regina, which was completed in 2007 with the assistance of the Saskatchewan Office of Energy Conservation and the Saskatchewan Research Council. At an incremental construction cost of only 12 percent,[10] the home was designed to achieve a 90 percent reduction in purchased energy consumption. It features south facing front windows for passive solar gain, 220 square feet of solar collectors for space and hot water heating, R40.9 insulation for the main floor walls, R44 insulation for the basement walls and R80 insulation for the attic. Other features include an air to air heat exchanger, a waste water heat exchanger, Energy Star rated appliances, compact fluorescent lamps throughout

the house, a network of plastic pipes in concrete pilings to extract cooling from the ground for summer air conditioning and instantaneous monitoring of electricity consumption.[11] Such a house is practical and affordable and it is an example of the kind of home construction that should be actively promoted and publicly displayed across Saskatchewan.

An even more recent example of cost effective house construction is the net zero energy VerEco home developed by Ronn Lepage in tandem with building scientist Dr. Rob Dumont. This home also exemplifies the kind of public demonstration home that could be built in communities across Saskatchewan. It has been on exhibit since October 2010 at the Western Development Museum site in Saskatoon. After reducing total energy consumption through good design and reusing as much energy as possible, this home meets its remaining energy requirements with environmentally sustainable energy sources, particularly solar photovoltaic systems. It includes R100 attic insulation, 16 inch thick R60 walls and passive solar design. Like the Holzkaemper residence, it also incorporates a solar hot water system, heat recovery ventilation and drain water heat recovery.[12] Through careful planning and compact design, construction costs have been reduced to $128 per square foot.[13]

The Factor 9 House in Regina, Saskatchewan demonstrates the enormous reduction that can be achieved in home energy consumption. Source: Rob Dumont, PhD, Saskatchewan Research Council, 2007.

7 Financial incentives for exceeding building code standards

Once energy efficiency standards are established in a revised Saskatchewan building code, the Provincial Government should put in place financial incentives that encourage home builders and homeowners to build to levels of energy efficiency that greatly exceed the new code.

The state of Oregon illustrates what can be done with a combination of energy efficiency building codes and financial incentives. The Oregon government improves upon energy efficiency building codes every few years. In the interim, it applies financial incentives to encourage home construction well above the code, and as these construction practices become widespread, it makes many of them the basis for the next energy efficiency code upgrade.[14]

Other types of incentives can also be offered to homeowners who pursue super-energy efficient home construction. For example, when new homes are built to very high efficiency standards, it would be useful if these homes were assessed to verify their actual environmental performance.[15] The Province could help pay for such assessments to be done for homeowners and home builders and the results could be used to help improve future practise in home construction.

8 SaskEnergy should launch a major province wide energy efficiency retrofit program

To date, Saskatchewan has had some success with its financial incentive programs, particularly those encouraging homeowner initiated energy efficiency retrofit projects. Thousands of residents have participated. Participating residents have put up most of the financing, with a financial supplement coming from government. Despite this success, however, most buildings in our province have still not had major energy efficiency retrofit work. There is a need for the

Government of Saskatchewan to recognize that financial incentive programs and loan programs will not take Saskatchewan as far as it needs to go in the process of upgrading our building stock. The primary barriers are upfront financial cost and the coordination work and knowledge needed to plan and undertake energy efficiency projects.

The time has therefore come for SaskEnergy to play a much larger role in facilitating energy conservation retrofit work across Saskatchewan. SaskEnergy is well placed to facilitate energy efficiency retrofits to buildings on a very large scale for two reasons. First, well-planned energy conservation initiatives can quickly pay for themselves solely through energy savings. Second, in SaskEnergy, Saskatchewan has a well administered Crown Corporation responsible for delivering space heating services and with the capacity to co-ordinate province-wide energy efficiency programs.

I therefore suggest that the objective now should be to conduct energy efficiency retrofits of the vast majority of buildings in Saskatchewan. Over a phased 10-15 year time period, and only to the extent that capital costs can be fully recovered through energy savings, SaskEnergy should be instructed by the Provincial Government to offer to pay the upfront costs needed to assist building owners in Saskatchewan to undertake energy conservation retrofit work. SaskEnergy would need to borrow the money for such an endeavour and would need to carefully audit each proposed retrofit project to ensure that it will provide satisfactory and cost effective savings. In other words, in each case the energy savings from the retrofit would need to finance the capital and labour costs of the project and all associated administrative and debt financing costs.

Our experience to date with energy conservation projects suggests this is entirely feasible. Over the past decade, work done by Saskatchewan Housing Corporation and work supported by SaskPower, SaskEnergy and the Saskatchewan Environmental Society in retrofitting schools demonstrates that a considerable amount of well-planned energy conservation retrofit work can pay for itself in 5-9 years, solely through the energy savings.[16] For instance, an energy conservation retrofit project on seniors housing in Saskatchewan was launched in late 2001. The plan involved cutting natural gas consumption by 10% in hundreds of seniors units with a five million dollar investment spread evenly over five years. Saskatchewan Housing Corporation estimated the five million dollar capital cost would be fully recovered by year seven. In fact, it was fully recovered in less than six years.[17]

How could this kind of success be scaled up so that it benefited all taxpayers? I suggest that SaskEnergy upfront the cost of carefully planned, pre-approved energy conservation retrofit projects and audit the completed work to ensure it has been properly done. Projects should be designed so that SaskEnergy can fully recover the cost of each project through the energy savings that will accrue over a period not to exceed eight years. Homeowners' and commercial building owners' natural gas bills would essentially 'stay constant' until the retrofits were paid for, with the exception of unavoidable fluctuations in the North American price of natural gas that inevitably affect all SaskEnergy customers. Full cost recovery will be possible because SaskEnergy will be supplying 20-40 percent less natural gas to each retrofitted building, while charging the same total amount in monthly fuel billings that it had before the retrofit work was done.

By limiting the choice of retrofit work to items that fully pay back within eight years solely through energy savings, SaskEnergy's investment in each project would be fully recovered, while the building owner would receive the retrofit service at no extra cost. Once the retrofit costs for a project were fully paid for, the building owner would keep all further financial savings. Using this approach, hundreds of millions of dollars of

energy efficiency retrofits could be done across Saskatchewan, creating jobs, slashing fuel bills and cutting pollution.

Given the urgency of the global climate crisis and the short time frame now available in which to reduce greenhouse gas emissions, this is the kind of bold initiative that needs to be considered in order to cut greenhouse gas pollution on a much larger scale than has been achieved to date.

Other measures will still be needed to supplement this initiative, particularly for large scale energy conservation work. For example, there will be a need for a low interest loan fund to facilitate the implementation of large energy efficiency and greenhouse gas reduction initiatives that are designed to achieve deep reductions and have long payback periods. Such loans should be broadly available to individuals, businesses, co-ops, farms, First Nations, municipalities and non-profit organizations. Examples of the kinds of projects that should be considered for eligibility include: energy efficiency projects of over $10,000, with payback periods of more than eight years; neighbourhood district heating projects and methane gas recovery projects.

9 SaskPower should invest in electricity efficiency to curb the need to build new generating capacity

SaskPower has never given high priority to electricity efficiency, despite the fact that it represents the most cost effective way of meeting Saskatchewan's electricity needs. Helping customers use electricity more efficiently would also help our province avoid the construction of expensive new power plants that otherwise must be built to respond to growing electricity demand. Over much of the past decade, when Manitoba Hydro was typically spending $30 million per year on electricity efficiency, SaskPower would only spend 4-6 percent of that amount.[18] In the past two years SaskPower has begun to invest more in electricity efficiency programs and this change is welcome news, but as we shall see the current energy efficiency targets are weak.

California provides a good example of how electricity conservation measures can be used as an alternative to electricity generation. The California Energy Commission and the California Public Utilities Commission report that until the 1970s, per capita electricity use in California was rising steadily, and was only slightly lower than the national per capita figures for electricity use. In the mid-1970s California embarked on a major electricity efficiency program. As a result, per capita electricity use in California has remained stable at slightly over 7,000 kWh per person per year since that time, whereas national U.S. per capita electricity use has continued to rise steadily and by 2004 was over 12,000 kWh per person. The average cost of electricity efficiency programs in California is reported to be half the cost of base load generation. California's utility-run energy efficiency programs are reported to save energy at a cost of less than three cents per kilowatt hour, well under half the cost of building new electricity generation facilities.[19]

Saskatchewan's current electricity grid had generating capacity of 3,982 MW in 2010.[20] At a time when many other utilities are giving more attention to energy efficiency, SaskPower has weakened its energy efficiency targets for the next few years, cutting its 2017 target from 300 MW of savings to 100 MW of savings.[21] Instead, SaskPower should be instructed to achieve at least 300 MW of electricity savings by 2017 and at least 500 MW of electricity savings by 2021. SaskPower staff should be directed to pursue all electricity efficiency investments that are cheaper than the least cost option of building new generating capacity.

One of the largest opportunities for efficiency gains is 'lighting'. SaskPower should make on-site visits to residential and small business customers to directly install energy efficient lighting

in locations that get high daily use. Much of this work could be done for customers 'free of charge'. SaskPower should also offer financial incentives to install lighting controls, such as timers and occupancy sensors, so that lighting comes on only when needed.

SaskPower should also offer energy efficiency financial incentives and direct install services for larger commercial businesses. This would include not only commercial lighting replacement, but HVAC (heating, ventilation and air conditioning) equipment upgrades and motor replacements to upgrade energy efficiency. This kind of initiative should achieve a reduction in total electricity use of at least 15-20 percent for each participating business.[22]

The financial incentive programs should then be extended to many other areas including encouraging the installation of electricity efficient pumps, electricity efficient elevators, electricity efficient irrigation systems, electricity efficient retrofits to refrigeration facilities, electricity efficient compressed air equipment, electricity efficient dust collection systems and advanced controls for heating, ventilation and air conditioning systems.

Another large opportunity for efficiency gains is equipment replacement. When equipment breaks down, there is an immediate opportunity to replace it with the most energy efficient equipment available in the market place. Utilities in some jurisdictions provide generous financial rebates and technical help to ensure that the most energy efficient equipment choices are made. A good example is found in the small U.S. state of Vermont, where utilities cooperate together to deliver energy efficiency services through an organization known as Efficiency Vermont. Efficiency Vermont actively works with local wholesalers and retailers to encourage them to carry high efficiency products and is available to provide same day assistance to businesses that must replace equipment — with financial incentives aimed at encouraging the highest electricity efficiency choices that are commercially available.[23] In the three year period ending in 2008 Efficiency Vermont saved 287,000 MWh at levelized costs of 3.1 cents per kWh.[24] SaskPower customers would be well served by SaskPower adopting the energy conservation practices of Efficiency Vermont.

10 Incorporating renewable energy in both new and existing subdivisions

Saskatchewan's larger urban centers are growing steadily, but most subdivision design is taking no account of the climate crisis and the fact that fossil fuel use will need to decline very substantially over the next 20 years. To provide broad guidance to municipalities, the provincial government should amend its 'Statement of Provincial Interests' in the Planning and Development Act in such a way as to clearly signal to municipalities that zoning bylaws and new municipal plans need to give increased attention to energy efficiency, the use of renewable energy and greenhouse gas emission reduction.[25]

The Provincial Government should immediately begin to work with municipalities to incorporate passive solar design into all new homes, including ensuring that subdivision layout and street layout provides good south facing exposure for homeowners, an objective that is feasible for the vast majority of new homes. To assist municipalities with this task, the provincial government (in consultation with interested villages, towns and cities) should prepare a model municipal bylaw that can be adopted by municipalities wishing to maximize the use of solar energy in subdivision planning.

To encourage maximum use of solar energy, the provincial government should offer financial incentives for new and existing homeowners to install solar energy systems for space heating

purposes. This would supplement the assistance now in place to those who install solar systems for domestic hot water.

In addition, the provincial government should pass legislation to protect the solar rights of all Saskatchewan residents who have installed solar systems on buildings which they own.[26] Such legislation would mean, at the very least, that those who had solar access blocked in the future would receive proper financial compensation.

The Saskatchewan Government should also provide financial support to municipalities to facilitate the incorporation of renewable energy systems into future subdivision design. Some subdivision designs could focus on installation of renewable energy systems in individual homes — such as putting a solar hot water system into every house in a subdivision. Other installations could be on a neighbourhood scale. For example, a new neighbourhood could be developed with hot water as its heating source and that hot water could be heated using a bank of solar collectors that is either centrally located or strategically placed on rooftops and open spaces throughout the neighbourhood. In the far south of Saskatchewan, another option available to communities is deep geothermal energy. The Province could support a municipality transitioning off natural gas and converting to geothermal energy for home heating and commercial heating purposes. The pilot community could be helped to access the underground hot water reservoir and to install pipeline infrastructure for district heating.[27] Using a central community-based energy station, it would then be able to pump hot water to each home and business in the town.

To help advance communities transitioning to renewable energy, the Provincial Government should facilitate partnerships between interested Saskatchewan communities and communities in other parts of the world that have successfully adopted renewable energy technology on a large scale. For example, in Sweden and Denmark the use of wood pellets is widely applied for district heating. In Germany large scale solar heating projects have been successfully piloted on a neighbourhood scale in towns such as Crailsheim and Neckarsulum.[28] In the city of Rizhao in northern China, the municipal government has for some time now required that all new buildings must include the installation of solar hot water systems; over 90 percent of the city's households now make use of solar energy.[29] In France and Germany many communities have transitioned to geothermal energy. One example is the German town of Unterhacing, where the local mayor, a physics professor, has led a process to convert his community to geothermal energy using a deep underground hot water resource. That resource proved hot enough to meet both the community's electricity and space heating needs.[30]

While the incorporation of renewable energy systems can be most cost effectively done during new construction, existing urban neighbourhoods and rural communities that are interested should also be actively supported by the Saskatchewan Government in making the transition off fossil fuels to renewable energy. Applications should be sought from interested communities and provincial support should include both technical and financial assistance.

Once again, linkages should be encouraged with other communities in the world that are

successfully engaged in such a transition. For example, Växjö, a community of 78,000 people in Sweden has used biomass, geothermal and solar energy to meet 51 percent of its energy needs.[31] In Denmark, the residents of Samsø Island have used wind power to meet most of their electricity needs and in their villages and towns have replaced fossil fuels for space heating with district heating systems running on biomass energy.[32] One of the island's district heating systems also uses a bank of solar collectors. The people of Thisted, Denmark, with a population of 46,000 people, now obtain 82 percent of their heating needs and 92 percent of their electricity needs from renewable energy. Thisted has used a combination of more than 250 wind turbines, geothermal energy, waste heat from industry, solar energy, rapeseed oil, biogas and other biomass sources to reach this goal.[33]

11 A plan for renewable electricity installations by SaskPower

Saskatchewan currently has 854MW of hydro and 197MW of wind generating capacity in a system with total available generating capacity of 3,982MW.[34] Wind power capacity rose by 26 MW in 2011 when the Red Lily Wind Project came on line.[35] Wind power provides approximately 3 percent of the total electricity provided by SaskPower, while Saskatchewan based hydro provides between 15-20 percent, depending on water flow in a given year.[36]

The Provincial Government is planning some additional wind power capacity. It currently proposes to add another 175 MW of wind power to Saskatchewan's electricity system to be in service by 2015.

While the planning work being done on wind power is welcome, a bolder vision for renewable electricity is needed. In addition to the 197 MW of wind now in place, SaskPower should install at least another 600 MW of wind power, 125 MW of small scale hydro and 125 MW of biomass electricity by 2018. In addition, the transmission grid between Manitoba and Saskatchewan should be upgraded to allow for greater import of hydro electricity from Manitoba.[37] Finally, as elaborated on in the next section, strategic investments should be made to facilitate development of renewable energy sources such as biogas and solar power using feed in tariffs. These projects would be in addition to the SaskPower installations.

SaskPower's wind power projects should be developed at a diversified set of locations around Saskatchewan in order to reduce the intermittency of electricity production. With multiple and spread out locations, the wind is much more likely to be blowing at some of the turbine sites.[38] Wind turbines should be placed at least 1,000 metres away from residential homes to avoid noise problems and should be placed well away from migratory bird paths. In Saskatchewan, we are fortunate to be blessed with sufficient space to make these policies practical to implement.

To ensure that as much of the revenue from wind power development as possible stays in local communities, SaskPower should develop many of its new turbine locations in partnership with wind farm co-operatives and Rural Municipalities, in effect fostering joint ownership of new wind farms. Such a process will also result in the choice of wind turbine sites that have high acceptability in local communities.

Most of the opportunities for small scale hydro development are in northern Saskatchewan. These should be developed with the informed approval of, and in close partnership with, First Nations and Metis communities in the north.

A good starting point for utilizing biomass for electricity production is to make use of waste forestry residues that can be found near to forest fringe communities. In some northern communities, where homes are located close together, there is also potential to use the waste heat from

Seven Sisters Hydroelectricity Dam – Manitoba

the biomass electricity generation process for district heating purposes. Biomass for electricity generation offers excellent base load power and has the capacity to foster local community economic development.

SaskPower should increase hydro imports from Manitoba as a way of complementing wind power production and supplementing renewable energy production in our own province. Wind power and hydro complement each other very nicely and can be coordinated together at a very low cost.[39] SaskPower should therefore target to import additional hydro from Manitoba as soon as this can be arranged. First, existing transmission capacity between Manitoba and Saskatchewan should be fully utilized. Second, additional transmission capacity should be planned for so that Saskatchewan could ultimately import at least 600 MW of hydro power from Manitoba. The latter arrangements are likely to take over a decade to operationalize. As part of an agreement, SaskPower should also negotiate arrangements to sell some of Saskatchewan's wind power into Manitoba.[40]

In addition to transmission considerations, how quickly additional hydro can be purchased from Manitoba will also depend on the other export agreements that Manitoba Hydro has entered into by the time the Saskatchewan Government begins serious negotiations with the Government of Manitoba. Options for regular hydro imports from Manitoba that would have been readily available to Saskatchewan a short time ago are becoming somewhat more limited as Manitoba Hydro makes long term commitments to export more power to U.S. states seeking to increase the renewable energy component of their electricity mix.[41] To date, Saskatchewan has not expressed firm interest in large hydro purchases from Manitoba. However, Saskatchewan and Manitoba have launched a feasibility study to look at the potential for increasing transmission capacity between the two provinces.[42]

12 Policies to facilitate large scale investment in renewable power

Saskatchewan is in the fortunate position of having a publicly owned crown utility for electricity generation. Cabinet and SaskPower senior management could clearly adopt the above mentioned 2018 renewable electricity targets as official policy of SaskPower and set about implementing them through direct public investment.

However, the Saskatchewan Government would be wise to supplement this by establishing a broader set of more formal policies that will help drive a renewable electricity agenda. Such policy measures are now common practice around the world. At least 83 countries have formal policies that promote renewable power generation.[43] In addition to direct public investment, three of the most commonly used policy measures are renewable portfolio standards, net metering at a sizeable scale and feed-in tariffs

A renewable portfolio standard is best established through an act of the Legislature. It would require in law that a specific percentage of Saskatchewan's electricity come from renewable sources as of a specific date. I suggest that a reasonable legally binding target would be that at least 40 percent of all Saskatchewan's electricity must come from renewable sources by 2020. Higher percentages could be set for the 2020-2025 period.

The 40 percent mandatory target would include Saskatchewan's existing large scale hydro projects. It will therefore be important for the Saskatchewan Legislature to specify a minimum penetration threshold for all renewable energy generation other than large scale hydro. For example, the Legislature could require that at least 20 percent of all Saskatchewan's electricity by 2020 must come from wind, biomass (including biogas and landfill gas), small-scale hydro and solar installations.

Such specifications are very common in other jurisdictions. In fact, in several U.S. jurisdictions, Renewable Portfolio Standards exclude large scale hydro entirely and focus only on requiring investment in other renewable electricity sources.

The most ambitious Renewable Portfolio Standard in the United States is that of California where utilities are required to meet 33 percent of electricity needs from renewable energy sources by 2020. Eligible technologies include photovoltaics, solar thermal electric, wind, certain biomass resources, geothermal electric, ocean wave, thermal and tidal energy, fuel cells using renewable fuels, landfill gas, certain smaller hydro facilities and municipal solid waste conversion.[44] Another U.S. state with a Renewable Portfolio Standard is Oregon where utilities that meet 3 percent or more of state electricity requirements must meet 15 percent of their supplied electricity from renewable energy sources by 2015 and 25 percent by 2025.[45] Massachusetts requires that 22.1 percent of electricity supplied by 2020 come from renewable sources, of which 15 percent must come from "new renewables" (not large scale hydro). Minnesota has set a Renewable Portfolio Standard of 17 percent by 2016 and 25 percent by 2025. The state limits hydro projects to 100 MW in size. In all, 29 U.S. states now have Renewable Portfolio Standards.[46]

These U.S. examples illustrate that a legally binding commitment for SaskPower to meet 20 percent of its electricity sources from "new" renewable electricity sources by 2020 is ambitious, but entirely reasonable. Combined with existing hydro resources in Saskatchewan and some limited hydro imports from Manitoba, a 40 percent renewable portfolio target by 2020 for SaskPower is also achievable. When a 300 MW electricity efficiency target is added to this mix, it becomes clear that within eight years, Saskatchewan Power Corporation should be able to set a much more environmentally sustainable course for the energy future of our province.

Other policies, including net metering and feed in tariffs can then be used to supplement the direct renewable energy installations that SaskPower and its community based partners jointly undertake. The installations under these programs will also contribute to achieving the 40 percent Renewable Portfolio Standard.

Saskatchewan has the beginnings of a net metering policy which was adopted in early October of 2007. The policy permits SaskPower customers to install renewable electricity projects up to 100 kW in size and to sell the power produced to Saskatchewan Power Corporation as a way of offsetting their own electricity bill from SaskPower. Under the policy, SaskPower agrees to purchase renewable electricity — produced by the customer and fed onto the grid — at a price that is identical to the price at which the customer buys electricity from SaskPower. Thus, customers have been able to use their renewable electricity installation to reduce their SaskPower electricity bill to zero over the course of a full year.[47] Beyond this, SaskPower has no obligation to purchase renewable electricity from the customer. The Saskatchewan government has made available financial assistance to help cover 35 percent of the cost of installations up to a maximum grant of $35,000.[48] Solar, wind, low impact hydro, heat recovery, biomass, biogas and flare gas projects are all eligible, but virtually all installations to date have been wind turbines and solar photovoltaic systems. By early 2011 more than 180 installations had been completed.[49] The

Government of Saskatchewan stopped applications to the net metering program effective April 1, 2011.[50] At this point, the future status of the program is uncertain.

Where should net metering go from here? The time has come to take net metering one step further by permitting SaskPower customers to build larger and more cost effective renewable electricity installations. Groups of customers should be supported to come together and pool their financial resources to build a single larger scale installation, equivalent to their combined electricity use. SaskPower's net metering policy could also be modified to make it possible for villages and towns to submit applications for net metering and renewable energy development on behalf of a group of ratepayers. Such changes would allow for more optimum site selection for renewable energy installations and better economies of scale on approved projects. A provincial grant to help with grid connection and the cost of installation should be maintained and the maximum should be increased to accommodate larger projects. Instead of limiting projects to 100 kw in size, net metering projects should be allowed up to at least 1 MW.

Nova Scotia offers an example of a Canadian jurisdiction beginning to move in this direction. On March 21, 2011 the Nova Scotia Utility and Review Board approved a plan by Nova Scotia Power that would allow customers to supply electricity to multiple meters in a single distribution zone and to increase power generation limits from 100 kw to 1 MW.[51]

A third important policy measure is the feed-in-tariff. At least 50 countries and 25 states/provinces have adopted feed-in-tariffs.[52] In Saskatchewan feed in tariffs should become an important vehicle by which to involve renewable energy co-ops, First Nations, rural municipalities, farms, businesses and homeowners in developing renewable power sources. Feed in tariffs would guarantee the right of these groups to generate renewable electricity (well beyond their own electricity needs) and have it purchased by SaskPower. Furthermore, a feed-in tariff policy would establish specific prices that would be paid by SaskPower for different types of renewable electricity production. These prices would reflect actual cost of production and installation, plus a small return on investment over a 15-20 year period.

Feed in tariffs will be a particularly important mechanism by which to encourage the installation of biogas generation in rural Saskatchewan and the construction of Saskatchewan's first solar power plants.[53] These have been renewable electricity sources that to date SaskPower has shown little inclination to move into. I envision SaskPower co-ordinating these projects in such a way that there is an appropriate mix of renewable technologies available to meet the needs of Saskatchewan power consumers. SaskPower will want to have a mix of base load electricity sources combined with electricity sources that meet demand during peak business hours and electricity sources that are of a more intermittent nature. Solar, wind, small scale hydro and biomass projects will all have the potential to complement one another, but again the mix must be right.

The evolution of feed in tariffs in Canada is still in the early stages. Ontario is to date the only jurisdiction in Canada to use feed in tariffs as a means of driving a renewable energy agenda. However, the Nova Scotia government is about to implement feed in tariffs and has circulated a proposed tariff schedule for discussion.

In Ontario, the jump in renewable energy installations as a result of feed in tariffs has been impressive, with active participation from both the private sector and the community based sector. The establishment of feed in tariffs was ushered in with the passage of the Green Energy Act by the Government of Ontario in 2009. Following passage of the Act, in the one year period from

September 2009 to September 2010 the Ontario Power Authority received thousands of applications and approved contracts for 2,649 MW of renewable power.[54] Two thirds of the approvals have been for wind power projects. However, thousands of small scale rooftop solar projects have also been approved, along with Canada's first solar power plants. The growth in solar capacity has been remarkable. In the year 2009 alone, Ontario installed 46 MW of solar photovoltaic.[55] In 2010 Ontario installed 168 MW. With a total installed solar photovoltaic capacity that sat at almost 215 MW by the end of 2010, Ontario ranks second for installed solar photovoltaic capacity in all of North America.[56] This position was achieved less than two years after Ontario's feed in tariff system was introduced. The Ontario response suggests that if Saskatchewan was to adopt a feed in tariff program, there would be strong interest.

The Nova Scotia government's plan for feed in tariffs sets an important new precedent. As proposed, it would limit feed-in-tariffs only to projects in which a majority share is owned by a community organization.[57] This signals a very different approach from Ontario, where only 15 percent of awarded contracts have gone to community and First Nations projects and where the government has promoted major participation by transnational companies in the renewable energy field.[58] The latter policy has been subject to criticism, particularly when the Ontario government made special arrangements with Samsung, a foreign multinational company, who has now gained access to a substantial portion of the transmission capacity in southern Ontario.

My own preference is for a feed in tariff program in Saskatchewan that focuses on community owned projects. In effect it would be geared to encouraging the installation of renewable energy systems in which majority ownership is held by homeowners, farmers, local co-ops, universities, SIAST campuses, local municipalities and Saskatchewan First Nations reserves. It must be recognized that this approach will mean it will take more time to raise capital and to get renewable electricity projects implemented. However, when they are implemented it will be with strong support from local communities and in a context in which local economic and social benefits will be maximized.[59]

If we are serious about facilitating community based renewable energy development, there will inevitably be a need to build additional transmission capacity in Saskatchewan in order to access some of the best opportunities for utilizing renewable energy in our province. As other jurisdictions have developed their renewable energy resources, they have at times found transmission capacity to be a limiting factor. Decisions on increasing transmission capacity will have to be made strategically to maximize benefits for local communities and for all SaskPower customers. We will also want to take maximum advantage of renewable resource locations near existing transmission lines.

In summary then, I propose a mix of approaches over the next eight years to accelerate the building of a renewable electricity economy in Saskatchewan. SaskPower would build an additional 850 MW of installed renewable electricity. Some of this would be 100 percent owned by SaskPower (on behalf of the people of Saskatchewan). Some would be jointly owned by SaskPower and local renewable energy co-ops or local municipalities. The majority of SaskPower's projects would involve installation of large wind turbines at diversified locations across southern Saskatchewan, but SaskPower would also be expected to move forward with run of the river hydro and biomass development. In addition to the above mentioned installations, I propose two other policy vehicles to encourage renewable electricity expansion. One is an enhanced net metering program, which would encourage SaskPower customers to meet their own electricity needs through renewable energy installations on their properties or in conjunction with

other local homes, farms and businesses. Upfront grants would help cover a portion of installation costs and the permissible size of projects would be increased to 1 MW. Second, a feed-in-tariff program would be established, particularly to encourage installations of solar photovoltaic, small scale hydro, and biogas. The feed-in tariff program would not involve grants. It would be available to all Saskatchewan residents. It would facilitate both small and large renewable energy projects and would guarantee a fixed price for the electricity they generate that covers installation and operating costs over a 15-20 year time period, plus a modest profit. It would be geared to promoting majority ownership by community based enterprise including local co-ops and local municipalities. It is expected that together these initiatives would take Saskatchewan past the threshold of meeting 40 percent of our electricity needs through renewable sources — by 2020 — but 40 percent would be the minimum requirement. This requirement would be enacted in law and SaskPower would be held responsible for ensuring it is met.

13 Addressing greenhouse gas emissions in Saskatchewan's industrial sector

Saskatchewan's industrial sector, including mining and oil and gas, is rapidly expanding. It is an important source of jobs for our province, but the greenhouse gas pollution impacts that result from the current operations of many of our largest companies are problematic and environmentally unsustainable.

At present 35 large industrial and commercial customers account for 45 percent of SaskPower's load.[60] Many industrial customers pay much lower bulk rates on their electricity than do domestic, farm and commercial customers, meaning that they are in effect being subsidized by the Saskatchewan public. Moreover, it is the largest customers who are the primary driver behind the need to build additional generating capacity in Saskatchewan, and when that capacity is built for them by SaskPower, they do not pay anywhere close to the full cost of its installation. Nor do they pay for the greenhouse gas pollution costs associated with this new generating capacity.

In an earlier paper in this series, Mark Bigland-Pritchard noted that the electricity rates paid by large industrial users in Saskatchewan need to be increased.[61] The artificially low rates for large industrial customers are an obstacle to moving towards using environmentally sustainable forms of electrical production on our grid.

Mark also suggested that financial incentives should be established to encourage industrial customers to make use of combined heat and power.[62] Combined heat and power or co-generation is the simultaneous production of electricity and heat (from a single fuel source) for the purposes of using both products. A current example of combined heat and power in Saskatchewan is the 228 MW natural gas fired co-generation facility located at the Cory potash mine site near Saskatoon. All the electricity produced on the site is sold to the provincial grid, while the exhaust gases are sent through a waste heat recovery boiler for the purposes of steam production. The co-generation station turns about 57 percent of the natural gas's potential energy into electricity and steam. This compares to an average of 33 percent at a conventional power station. Meanwhile, greenhouse gases are only about a third of an equivalent sized coal fired power plant.[63] Clearly combined heat and power is an important policy tool by which to use energy more efficiently, curb greenhouse gas pollution and reduce our reliance on coal fired power plants. SaskPower should encourage its use in other potash mines and in other industrial settings. To this end it should undertake an audit of existing mines and industrial facilities and planned expansions to assess low cost co-generation options.

Beyond this, SaskPower needs to work closely with each large industrial customer to maximize opportunities for efficient use of electricity. Since the approaches to achieving energy efficiency vary somewhat within each industrial sub-sector, SaskPower needs to bring into its company more staff with industry-specific knowledge of best energy efficiency practises. Each staff person would then work closely with two or three large companies to help them improve their energy use practises. Regular energy use audits within large industrial facilities should be required by SaskPower with the view to cutting energy consumption in cost effective ways, and each company should be expected to plan together with SaskPower about what action will be taken on the recommendations that flow from these audits. Examples of the kind of measures that are likely to be taken include installation of energy efficient pump systems, installation of variable speed drives, fixing air leaks in compressed air systems, retooling changes to production lines to make them more energy efficient or installing advanced control systems to more precisely control industrial processes. Such measures often improve production benefits for the companies and cut down on waste. In circumstances in which such measures would save SaskPower substantial 'avoided costs', SaskPower should offer modest financial incentives to encourage industry to make these installations as quickly as possible.

When high energy use equipment breaks down in large industrial facilities and must be replaced, SaskPower should require that it be replaced with the most energy efficient equipment available on the market. This is an important strategy for avoiding the high costs that otherwise come with expanding Saskatchewan's generating capacity. Similarly, all new proposals for industrial development in Saskatchewan should be required to meet stringent minimum energy efficiency standards in both their design and their actual operation.

To date SaskPower has been meeting the needs of new industrial customers by expanding its fossil fuel generating capacity. Such a practise comes at a very high economic and environmental price because it significantly increases greenhouse gas pollution, at a time when Saskatchewan needs to be doing precisely the opposite. It is therefore time for a major policy shift. SaskPower should make it clear to all new and expanding industrial customers that most of their power needs in the future will be met through a combination of co-generation, renewable electricity installations and hydro imports. This will require higher electricity generation costs and while those costs should be amortized over time, the portion of the new electrical generation capacity that is required by industry should be paid for by industrial customers and not by the general public. Such a shift in policy should simply be viewed as part of conducting business in a socially responsible way. Without this policy shift, other SaskPower customers will incur undue expense in financing the transition to a renewable energy economy.

Finally, as mentioned earlier, Saskatchewan industry should be supported by government in implementing comprehensive demand side management programs aimed at reducing the total net energy costs incurred by each industry. The Saskatchewan government should facilitate Saskatchewan industry having access to the best energy conservation expertise in North America to help them accomplish these cost reductions.

14 A start to coal phase out

As renewable energy projects, cogeneration projects, and 300 MW of electricity efficiency measures come on line in Saskatchewan, 400 MW of electricity production from Saskatchewan coal fired power plants should be shut down over the next eight years, thus reducing SaskPower's carbon footprint.[64] Saskatchewan currently has 1,682 MW of coal fired generating capacity and

produced 62 percent of its electricity from coal in 2009.[65]

Beyond the 400 MW phase out discussed above, a more ambitious target for coal fired power plant shutdowns should be set, recognizing that precise timelines depend on the rollout of Saskatchewan based renewable energy projects and the scheduling of hydro imports from Manitoba, as well as on the degree that the conservation programs recommended in this paper succeed in ramping back SaskPower's current projections for electricity growth in Saskatchewan.[66]

Coal is the most greenhouse gas polluting of all the fossil fuels. Coal fired electricity releases much larger amounts of CO_2 into the atmosphere than generating electricity from oil or natural gas.[67] Such heavy reliance on coal by SaskPower is an environmentally unsustainable practice that needs to stop. A carefully planned phase out of coal fired power plants in Saskatchewan is long overdue.

The province of Ontario is to be credited for taking the phase out of coal fired electricity seriously. After a great deal of effort, which has included the rapid expansion of renewable electricity sources, the province of Ontario will shut down its last coal fired power plant by 2014. Ontario shut down four of its 19 coal fired generating stations in 2005, another four in 2010, and will shut down the remaining 11 units (4,484 MW) over the next three years.[68] The Government of Ontario has passed legislation to complete the phase out of coal fired power plants — the first jurisdiction in North America to do so.

A bulldozer pushes coal towards the SaskPower Boundry Dam power station. Photo by: Troy Fleece, Leader-Post.

Ontario is studying the feasibility of converting some of its remaining coal fired units to natural gas or biomass.[69] The Government of Saskatchewan should follow Ontario's lead in examining these options.

15 Applying strict greenhouse gas emission criteria to future energy investments

Since avoiding the worst consequences of climate change is one of the most important reasons to revamp our electricity grid, it follows that we should hold all energy technologies we install in Saskatchewan to a requirement that the life cycle greenhouse gas emissions associated with their installation and operation is very low. This intense scrutiny should be applied to every energy technology including the renewable energy technologies advocated in this policy paper. While emissions associated with renewable energy technologies installed on electricity grids are usually low, this is not the case in every circumstance. The Saskatchewan Government should therefore require full disclosure of all greenhouse gas emissions associated with the manufacture, installation and operation of all new installations on Saskatchewan's power grid.

An example of the need for such criteria is the growing use of nitrogen trifluoride (NF3) by the electronics industry. This colourless, odourless, non-flammable gas is used for equipment cleaning. It is also used for etching microcircuits in the manufacturing of thin-film photovoltaic cells.[70] Nitrogen trifluoride is not yet regulated under the Kyoto Protocol, so there is limited formal reporting of its use. Yet it is 17,000 times more powerful in its heat trapping capacity than an equal mass of carbon dioxide.[71] Moreover, it's concentration in the atmosphere is steadily rising.[72] Once emitted, it persists in the atmosphere for 550 years.[73]

Clearly, the Saskatchewan government will want to favour the use of solar photovoltaic systems that minimize or avoid atmospheric release of NF3, and more broadly, that result in the release of the smallest possible quantities of greenhouse gas emitting substances throughout their life cycle. This may ultimately require Saskatchewan regulations which prohibit the sale or installation of a particular technology that is too greenhouse gas intensive.

The need for rigour in assessing greenhouse gas impacts extends to looking at how renewable energy technologies impact on overall grid emissions. For example, in Manitoba, the use of geo-exchange in home heating will have a very positive greenhouse gas impact, since the electricity source to run the geo-exchange system is coming from hydro. In Saskatchewan, where the majority of electricity comes from coal, the extra electricity use associated with a geo-exchange system makes geo-exchange a less advantageous installation from a greenhouse gas point of view. Thus, subsidy of geo-exchange in Saskatchewan should go hand in hand with the geo-exchange system drawing upon a renewable energy source for its electricity.

16 Key policy ideas discussed earlier in this series

In three excellent papers earlier in this series, Mark Bigland-Pritchard has raised other important policy initiatives that could take us closer to the goal of achieving a sustainable energy policy in Saskatchewan. I want to highlight here some of the important policy ideas that Mark has proposed. These include:

1. SaskPower should seek to achieve an optimum mix of wind power and solar photovoltaic power. When combined together these two sources of electricity will be less variable than either is on their own. In the short term the variability in wind and solar electricity output can be backed up by natural gas, but in the medium term these variable sources should be backed up by renewable energy sources such as hydro and biogas, both of which are dispatchable (i.e.: quick response).[74]

2. As the development of renewable energy technologies becomes a higher priority for government, there will be significant employment opportunities in the installation and maintenance of renewable energy systems and in retail sales for renewable energy systems. Provincial incentives should be put in place to maximize job opportunities in Saskatchewan associated with installation of renewable energy systems — for example, incentives should encourage the in-province sourcing of the towers for all Saskatchewan wind turbine installations.[75]

3. SaskPower should establish "an accelerated timescale for introduction of smart grid technologies." Mark emphasized that these technologies would result in a more reliable, less wasteful grid that is better suited to renewable energy, less prone to outages and "designed through price variations to enable the active participation of consumers in optimizing grid management".[76]

4. Priorities for research and development — with the view to their application in Saskatchewan — should include concentrating solar power, hybrid power stations, electricity storage options and the development of biochar. SaskPower should also research the best technology on the international market for pyrolysis and gasification of organic materials.[77] Of these, I consider research on electricity storage to be the most urgent. A full resolution of the storage issue would allow enormous expansion of wind power installations in our province.

5. Criteria for ethical biomass development should be established. Examples of important criteria include achieving a large, positive

net energy output, achieving substantial net reductions in greenhouse gas emissions, ensuring there is no added threat to important wildlife habitat or biodiversity, and ensuring that First Nations are fully consulted, that all treaty obligations are observed and that First Nations livelihood and traditional ways of life are protected.[78] I would add to this the importance of ensuring sufficient organic matter is maintained to support long term fertility of Saskatchewan's agricultural and forest soils.[79]

6. An important policy focus should be to promote local ownership of renewable energy systems, giving local ownership strong preference over the sale of renewable energy assets to out of province operators.[80]

7. It is not enough to add sustainability to the mix of electricity generation in Saskatchewan. Rather the entire generation mix should be shaped by the principles of environmental sustainability.[81] This sustainability imperative should not just be applied to electricity generation, but to all future economic development in Saskatchewan.

17 Conclusion

For our population size, Saskatchewan has a remarkable array of renewable energy resources. We are blessed with far more renewable resources per capita than the vast majority of provinces and states across the world. What we are lacking is the government policies needed to properly utilize these resources. This paper has explored some of the policy directions that would help us start the process of developing our renewable energy potential.

The practicality of making a steady conversion to renewable energy in Saskatchewan becomes clear as we look around the world and see the effects of progressive policies being implemented in much of the United States and Europe. The effect of those policies has been to spark remarkable investment in renewable energy technologies. ***In 2008 and again in 2009 more new electrical capacity was added to the grids of the United States and Europe from renewable sources of energy than from conventional power plants running on fossil fuels or on uranium fuel.***[82] Simply put, in both the U.S. and Europe, installation of technologies such as wind turbines, solar panels and biomass generation plants outstripped all new nuclear power installations, new coal fired power plants and new facilities that burn natural gas for generating electricity combined.

On a global basis renewable energy installation is also impressive. Of the approximately 300 Gigawatts of new electricity generating capacity added to the electrical grid system around the world between 2008 and 2009, 140 Gigawatts came from renewable energy.[83] Clearly, renewable power has come of age and its application in so many other jurisdictions around the world illustrates what could be done in Saskatchewan.

Looking to the future, the Intergovernmental Panel on Climate Change recently completed an exhaustive study of the potential of renewable energy around the world over the next forty years. It brought together over 120 leading energy experts to compile a comprehensive assessment of the role that renewable energy can play in addressing the climate crisis. It concluded that, with the right set of public policies, renewable energy could meet as much as 77 percent of the world's energy demand by 2050. Ramon Pichs, one of the Co-Chairs of the international working group emphasized: "The report shows that it is not the availability of the resource, but the public policies that will either expand or constrain renewable energy development over the coming decades."[84]

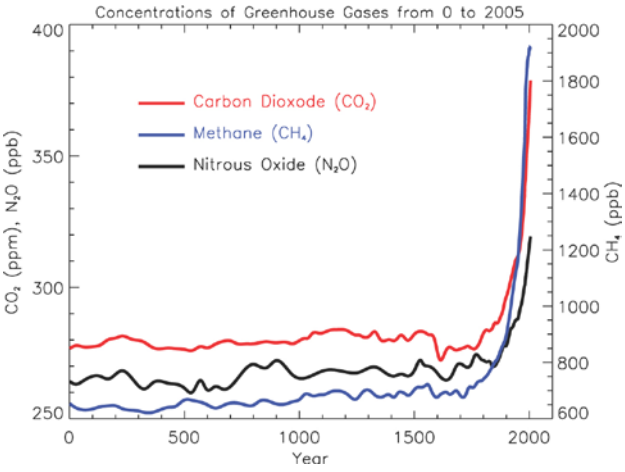
Thus, the challenge for Saskatchewan is to put the right public policies in place and to build a renewable energy society that is an example for the world to follow.

Climate Change Update

The most urgent purpose of 'greening' Saskatchewan's electricity grid is to reduce Saskatchewan's greenhouse gas emissions and move our province onto a more environmentally sustainable power supply. We began this series of Greening the Grid articles with an overview of climate change. We end it with a series of four short articles that provide an update on the climate change issue, in both a global and a Saskatchewan context.

The first two articles examine two of the consequences of climate change to which Saskatchewan is most vulnerable — intense precipitation events that result in floods and prolonged periods of severe drought. The common element in both cases is that climate change disrupts the hydrological cycle, increases uncertainty and increases the likelihood of extreme events. The third article examines another consequence of climate change that has huge social justice and environmental implications — sea level rise. One of the focuses of the article is a discussion of the Canadian contribution to sea level rise. The fourth article updates readers on the current status of global greenhouse gas emissions and an estimate of the amount of time we have left to act in order to avoid the worst consequences of climate change.

Atmospheric concentrations of important long lived greenhouse gases over time.



Source: IPCC Fourth Assessment Report, Climate Change 2007

Flooding Driven by Climate Change is a Growing Concern in Saskatchewan and Around the World

One of the largest and most serious consequences of fossil fuel use, deforestation and the other industrial processes that emit greenhouse gases is the significant changes this pollution brings about in the hydrological cycle.

The United Nations Intergovernmental Panel on Climate Change (IPCC) has observed that warming across our planet — that has occurred as human produced greenhouse gases build up in the atmosphere — has already led to an increase in heavy precipitation events in most areas.[85] Heavy downpours have become more frequent and more intense over most of North America in recent decades. These events now constitute a larger percentage of total precipitation.[86]

Extreme precipitation is controlled by the availability of water vapour, and that availability increases as the atmosphere warms.[87] Each 1°C of warming increases the moisture holding capacity of the atmosphere by about seven percent.[88]

In their June 2008 publication entitled Climate Change and Water the Intergovernmental Panel on Climate Change predicts that the frequency of heavy precipitation events will very likely continue to increase over most areas of the world during the 21st century because of rising greenhouse gas emissions.[89]

No single extreme precipitation event is necessarily associated with climate change. However, since the IPCC prediction was made, many events around the world have occurred which appear to be consistent with the trend anticipated by climate scientists. Further time and analysis are required before final conclusions can be drawn.

2009, for example, saw several new records for rainfall in a 24 hour period. Two prominent examples were the United Kingdom and the Philippines. The United Kingdom set a record for intense rainfall on November 20, 2009 when 314 mm (12.3 inches) of rain fell in Cumbria county in 24 hours.[90] On September 26, 2009 a record 400 mm (16 inches) of rain fell on Manila in 24 hours. Eight percent of Manila was submerged in flood waters.[91]

In 2010 severe rainfall events were notable for the large scale on which they occurred, as well as for their severity. For example, in May of 2010 Poland's Prime Minister Donald Tusk reported to Parliament that flooding in his country was on a scale "without precedent in the past 160 years".[92] In July and August of 2010 devastating floods hit Pakistan. Twenty million people were affected and at least six million had urgent need for food, clean water and health care. The flooding constituted the country's biggest ever humanitarian crisis.[93] Eleven million Pakistanis were displaced from their homes.[94] The July-August 2010 floods extended into northwest China, North Korea and Indian-controlled Kashmir.[95] More than 15 million people were displaced in China.[96] In Columbia in 2010 major flood events in April and again in June each displaced 1.5 million people. Other major flood events during 2010 displaced one million people in Thailand, 810,000 people in Mexico, 560,000 people in Nigeria and 523,000 people in India.[97]

Finally, in December of 2010 and early January 2011 hundreds of thousands of people were affected by relentless flooding in northeast Australia. Queensland suffered the worst flooding in its recorded history.[98] The flooding affected 86 towns and inundated 30,000 homes and businesses in Brisbane. 460 mm of rain fell in Brisbane in one week. In total, the Australian flood zone stretched over an area bigger than France and Germany combined.[99]

The number of natural disasters reported has doubled from around 200 to over 400 a year over the past two decades.[100] In 2010 over 90 percent of disaster displacement within countries was caused by climate related hazards, primarily storms and floods. In 2010 these climate-related disasters displaced 38.3 million people.[101] In June 2011 in reflecting upon these numbers, the UN High Commissioner for Refugees called the issue of climate-related displacement "the defining issue of our times" and called on the international community to make a greater effort to reduce greenhouse gas emissions.

Saskatchewan has also had a significant increase in flood related disasters in recent years, largely due to intense precipitation events. The result has been a sharp rise in spending under Saskatchewan's Provincial Disaster Assistance Program (PDAP). While annual PDAP spending consistently remained under $2.3 million in the first half of the decade, the years from 2006 through to 2010 saw PDAP spending of $15.1 million, 9.8 million, $31.3 million, $14.4 million and at least $25 million.[102] (The Public Accounts for the 2010 fiscal year were not yet available at the time of writing.) The bulk of the spending between 2006 and 2010 has been to assist communities and families impacted by uninsurable flood damage.

In 2010 more than 200 Saskatchewan municipalities were declared eligible for disaster assistance under PDAP.[103] Several Saskatchewan cities were hit by intense precipitation followed by flooding including Yorkton, Saskatoon and North Battleford.[104] The Trans-Canada highway was washed out near Maple Creek and the town itself was flooded. Perhaps most serious of all, one third of Saskatchewan's farmland was flooded and could not be seeded.[105]

The increase in damages from intense precipitation in Saskatchewan over the past five years is entirely consistent with predictions climate scientists have made about how the climate would change if concentrations of greenhouse gases in the atmosphere continued to rise. Further research is needed to determine the precise role of climate change in these major flood events.

Water Stress in Saskatchewan and in Much of the World Will be Made Worse by Rising Global Temperatures

In the calendar year 2010 global land and ocean annual surface temperature tied with 2005 as the warmest year on record.[106] Since the 1960's, every decade has seen higher global average temperatures than the previous decade. The average global temperatures in the past decade – from 2001 to 2010 — are the highest ever recorded for a 10 year period since the start of instrumental climate records.[107] With respect to average annual global temperatures, the ten warmest years on record have all been since 1998.[108]

In 2010 Canada experienced its warmest year ever with national temperatures exceeding annual averages by 3°C. In most of Nunavut and northern Quebec temperatures were at least 4°C higher than normal.[109]

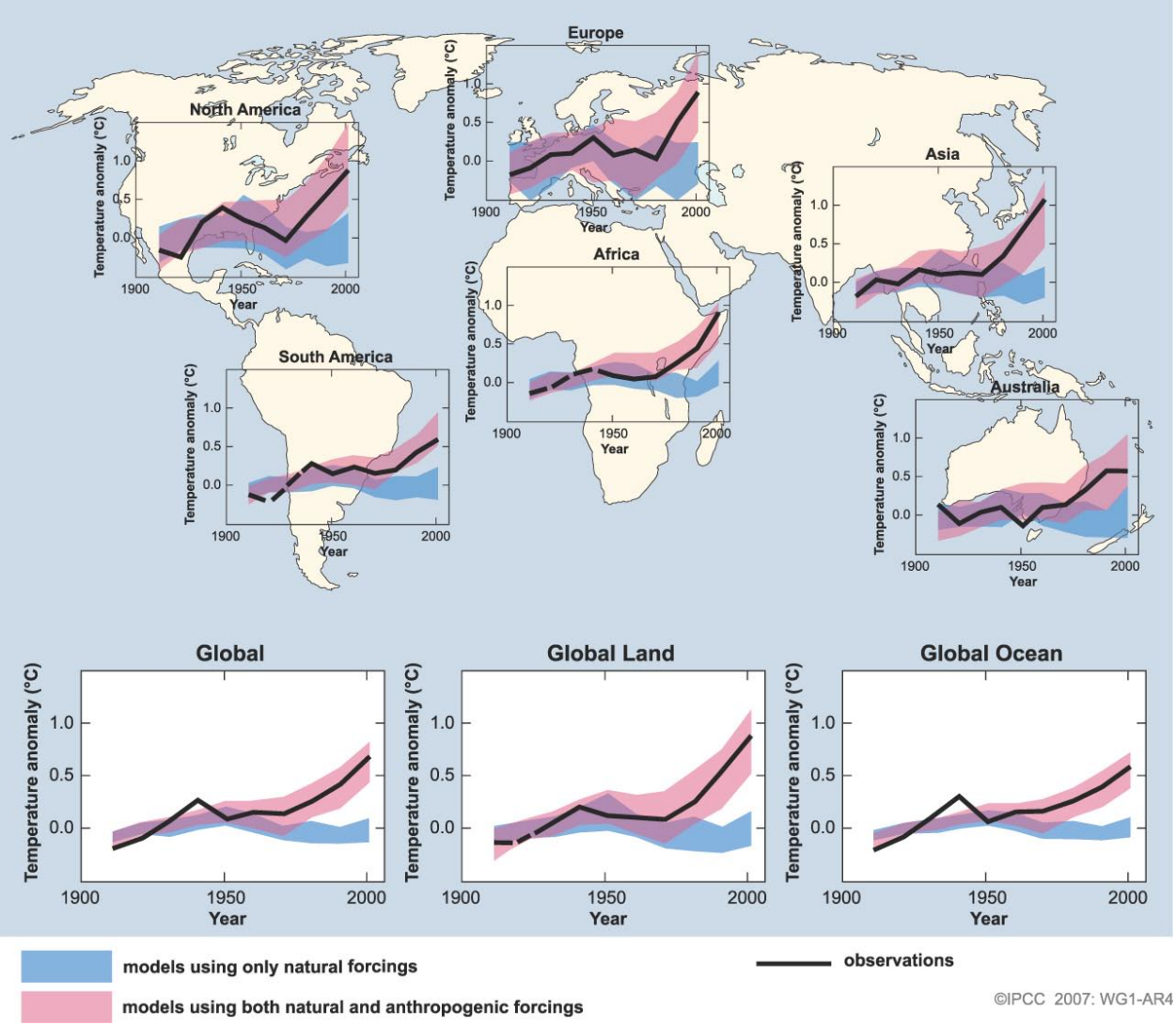
In Russia record temperatures during the summer of 2010 resulted in a heat wave that claimed 5,000 lives and caused hundreds of forest and peat bog fires.[110] Pakistan experienced its highest ever recorded temperature at 52.5°C.[111] Temperature records were also set in Ukraine, Finland, Kuwait, Chad, Burma, Niger, Sudan and Saudi Arabia.[112]

All of these developments are consistent with the kind of changes in climate that the international scientific community has been predicting would occur in some parts of the world as a result of the large scale release of human produced, heat trapping greenhouse gases into the atmosphere.

If current greenhouse gas emission levels are not curbed significantly, scientists forecast that the average global temperature could rise by between 1.8 and 4°C above the 1980-99 average by the end of this century.[113] These levels of temperature rise are certain to increase water scarcity in many parts of the world. Climate scientists expect warming to be more pronounced towards the poles, so Canada can expect a much larger temperature rise than the global average.

At present over one billion people on our planet experience water scarcity.[114] Most of them live in dry land areas. The number of people affected by water stress has been steadily rising. For example, during the past decade California, Southwest Australia and Kenya have been hit with consecutive years of devastating drought, shaped in part by climate change.[115] In the African Sahel, a semi-arid land stretching from the Atlantic Ocean to the Red Sea, rainfall patterns have

Global and continental temperature change over time.



Source: IPCC Fourth Assessment Report, Climate Change 2007

steadily declined for more than a decade. Last year approximately 10 million people in the African Sahel suffered food shortages largely brought on by the changing climate.[116] The World Water Assessment Programme reports that globally very dry areas (land areas with a Palmer Drought Severity Index of 3.0 or less) have more than doubled since the 1970s.[117]

The Intergovernmental Panel on Climate Change (IPCC) forecasts that in some African countries climate change will result in yields from rain-fed agriculture declining by 50 percent as early as 2020.[118] In the coming decades, the IPCC also forecasts a serious decrease in water resources due to climate change in the Mediterranean Basin, northeast Brazil and the western United States.[119] The National Science and Technology Council of the United States has observed that in parts of the U.S. "many plants and animals in arid ecosystems are near their physiological limits for tolerating temperature and water stress and even slight changes in stress will have significant

consequences".[120] The United Nations forecasts that by 2030 a serious consequence of rising global temperatures will be the dislocation of citizens because of water scarcity. As temperatures rise and evapotranspiration increases, UN agencies expect that, at a minimum, tens of millions of people will be displaced.[121]

Saskatchewan is prone to drought and will not be exempt from these global trends, although our northerly latitude will likely delay how quickly we feel their full effect. Southern Saskatchewan's hydrology has been historically characterized by low precipitation. In the low precipitation years, most water evaporates leaving little available for runoff. As a result, local water resources are often limited and very sensitive to a change in climate.[122]

Scientists predict that in the earlier part of this century, climate change will result in higher precipitation levels in Saskatchewan. This will often translate into prairie streams having higher spring runoff. However, as the century progresses the outlook shifts significantly. Increasing temperatures are very likely to result in longer periods of evapotranspiration and drier soils, particularly in summer.

Scientists at the Prairie Adaptation Research Collaborative in Regina forecast that later in this century there will be sharp drops in runoff and stream flow to wetlands and small prairie rivers as a result of climate change. In effect "evapotranspiration, driven by warmer overall temperatures, overwhelms the effect of increased precipitation, and leads to drier conditions."[123] By 2080 PARC scientists expect Saskatchewan to face more arid conditions with potential for much higher water stress.

The Royal Canadian Geographical Society and the National Round Table on the Environment and the Economy have recently published a map of Canada that projects climate impacts on the Prairies. They identify much of southern Saskatchewan as being at risk of desertification as global average temperatures approach 2°C above pre-industrial levels.[124] In addition to increased drought, they project that wildfires will be more frequent and that runoff into the South Saskatchewan River basin will significantly decline.[125]

Sea Level Rise Offers an Example of the Long Term Consequences of Today's Environmental Pollution

Sea levels are rising globally at 3.4 mm per year and the rise has been accelerating, a phenomena of special concern to the residents of coastal communities.[126] 160 million of the world's citizens live in areas that are less than one metre above current sea level.[127]

In many coastal communities around the world, planning is underway for sea level rise in the range of 0.7 metres to one metre by the end of the century. New evidence is leading many city planners and governments to conclude that earlier estimates by the Intergovernmental Panel on Climate Change regarding sea level rise may be too conservative. Those earlier estimates put sea level rise at between 0.18 and 0.59 metres by the period 2090-2099.[128] Earlier this year, for example, the Government of Australia released scenarios for sea level rise in the coastal capital cities of its country. The low scenario estimates sea level rise at 0.5 metres by the end of 2100, which is assumed to be unavoidable. The medium level scenario is for a sea level rise of 0.8 metres; while the high end planning scenario is for a 1.1 metre rise.[129]

The rise in sea levels is being driven by the higher temperatures associated with human produced greenhouse gas emissions. First, warmer temperatures are causing seawater to expand. Second, land based glaciers and polar ice sheets are melting and thus adding to the volume of water in the oceans.[130]

The scale of the melting is extraordinary. For instance the glaciers and ice caps in the Canadian

Arctic Archipelago lost an average of 31 billion tonnes per year between the years 2004 and 2006. Scientists estimate this rose to an average of 92 billion tonnes per year from 2007 to 2009. In just six years the Canadian Arctic Archipelago lost the equivalent of three-quarters of the water in Lake Erie and added approximately one millimetre to the depth of the global ocean.[131]

The World Glacier Monitoring Service monitors the status of approximately 100 glaciers around the world. It reports a loss in average thickness of these glaciers of 12.5 metres (water equivalent) since 1980.[132] The director of the Monitoring Service, Professor Wilfried Haeberli, warns that many glaciers are set to disappear in the next few decades. Those in lower mountain ranges like the Alps and the Rockies are especially vulnerable.[133]

A large number of small island nations are at high risk from the cumulative impacts of this melting process. Already many of these countries are reporting serious problems with coastal erosion, flooding and salinization of water supplies.[134] Some island nations are even being forced to plan for the day when they will abandon their homeland. For instance, the Maldives, a country with 1200 islands and coral atolls is at such risk that the President has entered into discussions with Sri Lanka, India and Australia, with the view to buying a new country for his 300,000 citizens.[135]

The risk to coastal communities does not just come from higher sea levels, but from the more dangerous coastal surges associated with them. A good Canadian example is Tuktoyaktuk, North West Territories, where the surging Beaufort Sea is damaging town infrastructure and eating away at community roads and runways.[136] In northeast Norfolk in the United Kingdom, the community of Happisburgh is facing such serious coastal erosion that many homeowners are being forced to abandon their homes entirely.[137] On the West Bengal side of the Sundarbans (India), Lohachara Island has already disappeared underneath the waves, leaving 10,000 people homeless and forced to relocate.[138] In neighbouring Ghoramara Island, another 7,000 people have been forced to move out of their homes permanently by the rising seas. These communities provide a tiny window of what is to come if greenhouse gas emissions are not curbed quickly.

The worst coastal surges are caused by major tropical storm systems. The Intergovernmental Panel on Climate Change predicts that more intense tropical and extra-tropical storms are expected to combine with higher sea levels to create "devastating impacts" for unprotected low lying areas.[139] IPCC scientists express concern for the increased potential for inundation in heavily populated cities on deltaic plains such as Bangkok and New Orleans and note that Bangladesh and parts of West Bengal, India could experience "acute effects" from global sea level rise.[140] They state: "Many millions more are projected to be flooded every year due to sea level rise by the 2080s."

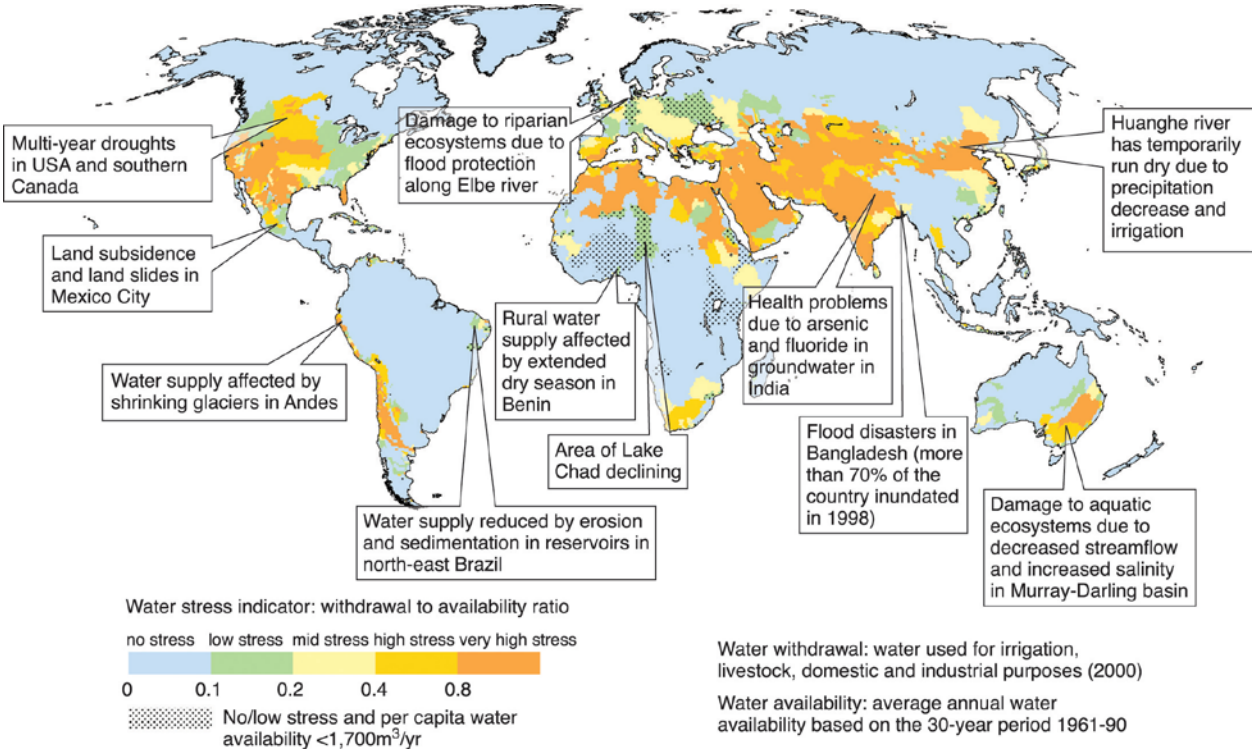
Even more important, scientists warn that if rising greenhouse gas emissions are not curbed sharply, global sea level rise will continue for centuries and will thus cause very large scale displacement of those who live in and near coastal communities.[141] In effect, today's environmental pollution practices will reshape the globe for centuries into the future.

How Long Do We Have to Act in Order to Prevent Dangerous Climate Change?

The United Nations has warned that a continued failure to address greenhouse gas emissions and their consequences is putting at risk decades of progress in improving life for the world's poorest people.[142]

The United Nations has endorsed the view that global average temperatures should not be allowed to rise more than 2°C relative to their

Examples of current vulnerabilities of freshwater resources in the world.



Source: IPCC Fourth Assessment Report, Climate Change 2007

1980-99 average.[143] This so-called 'maximum acceptable temperature' has been hotly debated within the UN. The vast majority of developing countries have argued it should be 1.5°C, but most developed countries have insisted on 2°C. At 2°C the Intergovernmental Panel on Climate Change has informed the UN that up to 30 percent of species on the globe will be at increased risk of extinction, most coral reefs will be bleached, cereal productivity will have declined at low latitudes, millions more people will be experiencing coastal flooding each year, there will be substantially increased damage from storms and intense precipitation events, there will be increased drought in mid-latitudes and semi-arid low latitudes and hundreds of millions of people will be exposed to increased water stress.[144]

A large body of climate scientists are of the view that in order to avoid exceeding 2°C, greenhouse gas concentrations in the atmosphere need to be held to between 450 ppm and 500 ppm carbon dioxide equivalent. (Carbon dioxide equivalent (CO_2e) is a measure that not only accounts for the concentration of carbon dioxide in the atmosphere, but also the concentration of other critical heat trapping greenhouse gases including nitrous oxide, methane and the fluorinated gases.) Even at these concentrations, there are substantial risks that the 2°C mark could be exceeded.[145] A complicating factor is that there is a significant time delay between reaching a particular greenhouse gas concentration and the associated temperature rise. A second complication is that not all the additional heat is held in the atmosphere — much of it is absorbed by the oceans[146] — a factor that is helping to explain why the Greenland ice cap is melting more quickly than scientists first predicted.

How long do we have to act in order to prevent the dangerous changes that come with a 2°C rise in average global temperature? Recent

increases in CO_2e have been occurring at over two parts ppm per year. Our current CO_2e level in the atmosphere is approximately 438 ppm.[147] Therefore, if current fossil fuel extraction and consumption rates stay constant, the 450 ppm CO_2e concentration is likely to be reached within six years, while the 500 ppm CO_2e concentration will be reached within 30 years. These dates can be extended if global fossil fuel consumption rates are steadily curbed. While I do not think it is possible to avoid the 450 ppm CO_2e concentration, 500 ppm CO_2e is still possible to prevent, but only with concerted global action to slash greenhouse gas pollution.[148]

If substantial action is not taken, climate scientists project that global average temperatures could increase by as much as 4°C over the course of this century, with catastrophic consequences.[149]

Adding to the urgency for emission reduction measures is the lengthy time periods most greenhouse gases remain in the atmosphere. For example, nitrous oxide emissions remain in the atmosphere for 150 years and methane emissions for 8 to 10 years.[150] In the case of carbon dioxide, approximately half of human produced emissions are absorbed by the oceans, forests and other land based plants within 30 years.

However, 20 percent of the human produced carbon dioxide emissions released today are projected to remain in the atmosphere for over 1,000 years.[151]

It is clear that if we don't reduce greenhouse gas emissions sharply now, future generations will be unable to reverse the resulting damage for a very long time. We need to approach greenhouse gas emission reduction with a war-time-like urgency. The generations alive on the Earth today will define the climate on Earth for hundreds of years into the future.

Acknowledgements

I would like to express appreciation to Mark Bigland-Pritchard, Brian Banks, Simon Enoch, Sandy Ervin, Dave Geary, Steve Lawrence, Cathy Holtslander, Dianne Manegre, Rick Sawa, Karen Weingeist and the Board of CCPA for the support and advice they have offered me during the course of the preparation of papers in this series. My thanks also to Ann Coxworth, Ken Belcher, Graham Barber, Lon Borgerson, Allyson Brady, Angie Blugg, Lorne Calvert, Doug Clark, Ewen Coxworth, Geoff Cunfer, Frank Dietz, Rob Dumont, Monique Dube, Gordon Edwards, Patricia Gober, Murray Hidelbaugh, Margaret McKechney, Sandra Morin, Bram Noble, Roger Peters, Maureen Reed, Joe Schmutz, Bing Si, Bill Wardell, Bert Weichel and the staff at Climate Action Network, the Saskatchewan Environmental Society and Efficiency Vermont for the insights and help they have offered me in order to gain a deeper understanding of the issues surrounding renewable energy, energy policy and climate change. Finally, I am very grateful for the love and support of my wife Louise Gagné who has always shared my belief that we can create a renewable energy society in the province of Saskatchewan.

Public Policies – A Response to Peter Prebble

By Mark Bigland-Pritchard

While this comment is mostly given over to friendly critique of Peter Prebble's paper, I should first note that our points of agreement are far greater than our areas of disagreement.

Peter sets out a policy framework which would be a truly massive improvement on the half-hearted approaches taken in Saskatchewan by both NDP and SaskParty governments since scientists first made the world aware of the grim reality of the climate change crisis in the late 1980s. If these policies were adopted, we would see a significant reduction in our carbon footprint, together with real opportunities for new sustainable industries and for regeneration of depressed rural areas of the province. It is unfortunate that Peter's political colleagues have not listened to him more carefully: I hope that his paper will give them some incentive to do so.

We face both a crisis and an opportunity. The truly appalling prospect of runaway climate change demands action, and demands it urgently and decisively. Both Peter and I share a deep commitment to address this crisis head-on. At the same time, the rapid development worldwide of energy efficiency, renewables and smart-grid technologies over the last twenty years has totally revolutionized the options available to us for meeting our energy needs and desires, and is already beginning in other jurisdictions to enable the building of a society which is not only more environmentally sustainable but more democratic, more self-reliant, more mutually-supportive and more inclusive. Again, both Peter and I share a deep commitment to put these deep Saskatchewan values into practice.

Where we differ is in the speed at which we wish to move, and in the extent to which we wish to transfer political power from centralized government bureaucracies into the hands of local communities.

Climate Change: Even More Urgent than Peter's Presentation Indicates

Climate science has moved quickly over the last few years. While rightwing ideologues have worked hard to discredit climate change theory, and — despite the facts of the case[152] — have succeeded in convincing many of the public, the reality is quite different. The Greenland and West Antarctic ice-sheets have been melting faster than most models had predicted. The Arctic Ocean is losing ice faster than predicted. The rate of release of methane from the arctic permafrost has begun to rise. Forest fires, together with pine beetles no longer reliably controlled by cold winters, have turned large sections of forest from carbon sinks to carbon sources. We are closer than we thought to at least some of the "tipping points" beyond which climate change could be uncontrollable by normal policy measures. (For an excellent introductory explanation of tipping points and why they impact on all of us, see the Wake Up Freak Out video at *http://notstupid.org.s3.amazonaws.com/WAKE-UP_LOUDER_HD.mov*[153]) At the same time, more detailed climate models, and better analysis of historic and prehistoric data, point in the same direction: this crisis is closer and more serious even than we had thought.

Hence Peter is already out of date when he cites 450 to 500 ppm CO_2 equivalent as an

appropriate target. For three years now, world-leading climate scientist Jim Hansen (head of the NASA Goddard Institute for Space Studies and Adjunct Professor at Columbia University Earth Institute) has been arguing on the basis of his findings for 350 ppm CO_2 in addition to reduction of other greenhouse gases.[154] This means that we need to do more than stabilize the atmospheric concentration — we need to reduce it from the present value of nearly 395 ppm. This implies a degree of urgency which is not present in current internationally-agreed targets. (However, tougher targets are supported publicly by at least one senior UN official — according to Christina Figueres, executive secretary of the UN Framework Convention on Climate Change, "Two degrees is not enough — we should be thinking of 1.5°C. If we are not headed to 1.5 we are in big, big trouble".[155])

Hansen has calculated that, in order to avoid climate catastrophe, we must "phase out coal emissions rapidly, and leave the unconventional fuels such as tar sands in the ground".[156] Carbon dioxide concentrations would then peak at 400 to 425 ppm, and would have to be reduced to 350 ppm through improved agricultural and forestry practices which cause more carbon to be stored in vegetation and the soil.

Hansen is convinced that it is still possible to avert catastrophe — but only by taking urgent action.

Other researchers compound this picture. Swedish researcher Johan Rockström adopts 350 ppm as the most likely "planetary boundary" in a broader analysis of the limits within which humanity can live safely.[157] A team led by Nathan Gillett at the University of Victoria has demonstrated that carbon dioxide levels — and hence warming — will remain high for hundreds of years even if emissions stop today — as natural cycles remove it from the atmosphere, stored carbon in the oceans will replace it.[158] Hence, the higher the concentration at which carbon dioxide is stabilized, the more intractable the problem. Peter may be correct in his judgment that we are unlikely to stabilize below 500 ppm, but if so there will need to be a massive, costly and most likely disruptive effort put into sequestration after this is achieved. It makes much better long-term sense to follow Hansen in aiming for a substantially lower stabilization point.

We can always hope that Hansen, Rockström, Gillett and the others are wrong — cutting-edge science often requires correction in the light of new information. However, these are researchers with a strong reputation. Since the 1992 Earth Summit in Rio de Janeiro, the basis of climate policy is supposed to have been the precautionary principle — if there is uncertainty as to whether urgent action is required, the burden of proof falls upon those who claim that it is not.

I therefore back Bill McKibben and 350.org in pressing for Jim Hansen's target to be central to public policy worldwide. If runaway climate change is to be averted, every jurisdiction must catch the urgency of the situation and play its part.

For this reason, I advocate an even faster shift to a sustainable energy economy than Peter proposes. Following European precedents, there is no reason why we should not be able to roll out at least 120 MW of new wind power capacity each year. With the cost of photovoltaics dropping rapidly, we can begin to plan for a significant solar contribution to our energy supply well before 2020. A large-scale plan needs to be developed for dispatchable hydro and biogas power within the same timeframe. And, most importantly, electrical energy efficiency measures can proceed at a much faster rate than Peter suggests: the 1% savings each year which I proposed previously in this series amounts to about 180 GWh of energy, and is most likely equivalent to about 300 MW of capacity.

Pursuing Decentralized Control of Energy and Choosing Appropriate Financial Incentives

The green energy economy offers tremendous opportunities for small businesses throughout Saskatchewan, working on energy-efficient components, products to enhance energy efficiency, high-quality building components, and components for renewable energy systems. It can also enable communities to take ownership and control of their power supply — a decentralized grid works much better with Saskatchewan's optimal renewables mix than it does with fossil fuels.

The potential outcome: more local jobs, and remote communities (whether First Nations, Métis or settler) better able to support themselves. The benefits for families and communities are considerable.

To maximize these benefits, ownership and control of power production facilities should, wherever possible, be under the control of local communities. This may be through a traditional cooperative, in which all shareholders have an equal vote. Or it could be through conventional businesses, but with a requirement that a certain percentage of the shares (say 75%) be held in the local area. Municipalities or local businesses could share in ownership. The point is that control is in the local community, not in a distant (albeit publicly owned) corporation in Regina.

This inevitably has implications for the future role and structure of SaskPower. The corporation has been vital in ensuring province-wide availability of electricity. However, a shift from the present centralized system to a distributed, networked grid requires governance changes to match. For as long as Saskatchewan depends on large centralized power stations SaskPower should manage them — they should not be privatized, nor even put into local community ownership. SaskPower should maintain its role as manager of the grid — a vital function as we move towards a situation in which smart grid technology manages complex arrangements for power export and import among local networks, and the distinction between producer and consumer becomes increasingly blurred. A central function for demand side management and for demand prediction will still be necessary. It should also become a centre of expertise on which communities may draw. It could be legitimate for SaskPower to be a shareholder in all new community schemes throughout the province. But the corporate culture must change, becoming less about command and control and more about facilitation and support. The optimum scale of the new renewables is such that a large measure of local democratic control is possible: if that is the case, then why continue to devolve that control to a distant office in Regina? Similarly, provided they can benefit from adequate financial support mechanisms, and have access to good technical, legal and administrative support, there is no reason why local initiatives could not drive the entire renewables revolution. It has been done in large sections of Denmark and Germany — so why not here?

In this context, I find Peter's three-level approach to financial support unnecessarily complex. If a well-designed portfolio of feed-in tariffs were put in place, net metering would be superfluous. And, while there is value in setting targets for renewables penetration, those targets can be achieved more effectively through adjustments to the feed-in tariffs than by the central diktats of renewable portfolio standards legislation. When the market can provide results without bringing economic injustice or environmental destruction in its wake, it makes sense to use market-adjusting mechanisms rather than central agencies. Judging by the experience of several European countries, an approach based on feed-in tariffs achieves better results more quickly and at lower economic cost.

Feed-in tariffs do, of course, need to be established at rates which are fair to both producers and consumers, and steadily reduced as the relative economics of the renewables continues to improve. There is much international experience from which we can learn — especially in Germany.

Further General Comments

I would like to conclude by putting this discussion in a broader context. The first four papers in this series focussed on the electrical sector. In his paper, Peter also addresses the low temperature heating sector (water and space heating in domestic, commercial and administrative buildings). We have not considered the measures required for transport, nor (except in passing) for industrial high-temperature heating. In addition to considering these four sectors of energy consumption, a comprehensive climate policy will also require policies to eliminate methane emissions from the oil and gas industry, and to radically reduce methane and nitrous oxide emissions of agricultural origin. A wide range of policy initiatives will be necessary if we are to play our part in successfully confronting the climate crisis and building a better world for our childrens' generation. Central to such policy initiatives should be the setting of a price on carbon. Sweden has had a carbon tax for two decades, during which its economy has thrived and its carbon footprint has reduced. (The current tax rate is $150 per tonne of carbon dioxide, with exemptions or partial credits for some sectors.) We would do well to follow suit, shifting the burden of taxation from income and jobs to the activities which threaten the future of human civilization.

As noted above, my disagreements with Peter Prebble are less important than the principles which we both wish to bring to public policy in Saskatchewan.

Acknowledgements

It has been a privilege to work with Peter on this series of papers; I would also like to thank all those others who have made this work possible: Cathy Holtslander, Karen Weingeist, Sandy Ervin, Rick Sawa, Steve Lawrence, Brian Banks, Simon Enoch, Dianne Manegre, Elizabeth Bekolay, the board of CCPA Saskatchewan, and numerous people who have donated to Green Energy Project Saskatchewan.

End Notes

1 Nicholas Stern. *The Economics of Climate Change* (Cambridge: Cambridge University Press, 2006), pp. 203 and 221-228. In his landmark climate change report for the Government of the United Kingdom, Stern notes that to stabilize the concentration of carbon dioxide in the atmosphere over the long term, emission levels will need to be cut by over 80 percent from 2000 levels. In future centuries, emission cuts may need to be far deeper still. Unfortunately, global emissions have risen sharply since the year 2000.

2 Environment Canada (2010), *National Inventory Report 1990-2008: Greenhouse Gas Sources and Sinks in Canada – The Canadian Government's Submission to the UN Framework Convention on Climate Change.*

Environment Canada "Greenhouse Gas Emissions Per Person And Per Unit Of GDP For The Group Of 8 countries, 1990 and 2008". (*http://www.ec.g.ca/indicateurs-indicators/defaultasp?lang=en&n=BFB1B3 98-1*) Accessed June 12, 2011. Canada's greenhouse gas emissions were 22.04 tonnes per capita carbon dioxide equivalent in 2008. Canada's emissions were 21.37 tonnes per capita in 1990.

Environment Canada (2011). *National Inventory Report 1990-2009: Greenhouse Gas Sources and Sinks in Canada – The Canadian Government's Submission to the UN Framework Convention on Climate Change, Part 3, Annex 14.8: Saskatchewan*, p. 69.

3 In 2008 55.7 percent of Saskatchewan's electricity supply came from coal. Saskatchewan Power Corporation (2009): 2008 Environment Report. Available at: *http://www.saskpower.com/environment/report/2008/pdf/2009complete.pdf Accessed on March 11*, 2010.

In 2009 62 percent of the electricity supplied to our province (19,864 GWh) came from coal. 75 percent of the electricity supplied by SaskPower-owned facilities (16,557 GWh) came from coal.

4 Peter Prebble. "Climate Change and Saskatchewan Public Policy" in *Saskatchewan Politics: Crowding the Centre*, edited by Howard Leeson. (Canadian Plains Research Centre, University of Regina, 2008), p. 432.

5 Workshop: Cost-effectively Meeting and Surpassing the 2012 Ontario Building Code for Low-rise Residential Housing, Sept 24, 2010.

By way of additional information, the Saskatchewan Home Builders have now been promoting Energy Star construction for at least four years, but only a small fraction of homes in Saskatchewan are actually built to the standard. One developer in Regina, however, is building all his company's new homes to the standard, demonstrating its viability. In 2007 the Provincial Government instituted a policy of paying $1,000 to all homeowners that build or purchase a new Energy Star home, as a way of encouraging Energy Star construction. In light of the measures taken to date, the next logical step is to integrate Energy Star into the Saskatchewan building code.

6 Based on Natural Resources Canada's Hot-2000 software, an Energy Star home can save the homeowner $800 to $1,000 annually in energy costs when compared to a conventionally constructed home. (For further detail refer to Energy Star Saskatchewan *http://energystarsask.ca/energy-star/benefits/*)

Moving to Energy Star would take the average new home to an E-80 standard. The 80 refers to a percentage scale in which 100 represents a home that produces an equivalent amount of energy to the amount it consumes.

Thus, Energy Star is still a long way from leading edge energy-efficient housing design.

7 Peter Prebble. "Climate Change and Saskatchewan Public Policy" in S*askatchewan Politics: Crowding the Centre*, edited by Howard Leeson. (Canadian Plains Research Centre, University of Regina, 2008), p. 442.

8 University of Berkeley researchers analyzed employment impacts of fossil fuels versus renewables over a 10 year period and found that while the coal industry only creates 3.9 jobs for each one million dollars invested, the wind industry creates 5.7 jobs for each million dollars of investment, and the solar industry creates 5.6 jobs. (Daniel Kaamen, Kamal Kapaidia and Matthias Fripp, "Putting Renewables To Work: How Many Jobs Can The Clean Energy Industry Create?" UC Berkeley: Renewable and Appropriate Energy Laboratory, April 2004 (updated January 2006), p. 12 (*http://rael.berkeley.edu/files/2004/Kammen-Renewable-Jobs-2004.pdf*)

Work by Brennan Louw, Jon Warren and Tim Wohlgemut suggests that while wind, biomass and small hydro all create more person years of employment per GWh produced than does electricity generation from either fossil fuels or nuclear power, the biggest employment gains come from an investment in solar PV. (Brennan Louw, Jon Warren and Tim Wohlgemut, "Economic Impacts of Solar Energy In Ontario: Executive Summary", November 2010, p. 2. Refer to bar chart titled 'Person-Years of Employment per GWh Produced'.

9 Under British Columbia's Greenhouse Gas Reduction Targets Act, all public sector organizations must report on actions taken to cut greenhouse gas pollution. 26 of BC's post-secondary institutions have prepared 'carbon neutral action reports'. For further information refer to LiveSmart BC – Carbon Neutral Action Reports (*http://www.livesmartbc.ca/government/advanced_education.html*)

The University of British Columbia is constructing the Centre for Interactive Research on Sustainability scheduled to open in 2011. Much of the building's heat and electricity will come from renewable energy sources. (*http://www.sustain.ubc.ca/hubs/cirs*)

At least 650 post secondary institutions in the United States have signed the American College and University President's Climate commitment to become 'carbon neutral'. For further information refer to Climate Neutral Network at *http://unep.org/CLIMATENEUTRAL/News/CNNetintheNews/USUniversitiesAimforCar*.

The University of Colorado's Boulder Campus, in a project undertaken with major assistance from Rockwell Financial Group, now has 472 solar photovoltaic panels operating on campus. (*http://ecenter.colorado.edu?energy-climate/whats-going-on-at-cu*)

The University of Vermont buys its electricity from a municipality that meets 67% of its needs through renewable electricity sources and is targeting to be 100% renewable by 2012. The College of the Atlantic has reduced greenhouse gas emissions 35% since buying electricity solely from a low impact hydro facility. (*http://www.greenreportcard.org/report-card-2010/schools/university-of-vermont* and *http://www.greenreportcard.org/report-card-2011/schools/college-of-the-atlantic*)

10 Dumont, Rob. "Moving Toward Net Zero Energy Homes: Canadian Prairie Contributions". TECA Presentation in Vancouver, B.C"., December 2007, p. 70.

11 Communities of Tomorrow, Canada Mortgage and Housing Corporation, Natural Resources Canada, Saskatchewan Office of Energy Conservation, Saskatchewan Research Council, University of Regina and City of Regina. "Factor 9 Home" pamphlet, 2007.

12 SaskPower Eneraction. "Canada's First Net Zero Home Exhibit: VerEco Home", 2011, p. 6-7.

13 Presentation by Ronn Lepage to members of the Saskatchewan Environmental Society, May 2011.

14 Meeting by Peter Prebble with Michael Grainey, Director of the Oregon Department of Energy and Michael Kendell, Senior Energy Analyst, Technology Development, Oregon Department of Energy, July 2006.

15 Programs that are helpful for an environmental assessment of homes include LEED for Homes and Passivhaus.

16 More than 70 Saskatchewan schools have now participated in the Destination Conservation Program. A large portion of capital investments made over the course of the program have been recovered through energy savings.

By way of a residential example, the condominium at 1700 Main Street in Saskatoon has undertaken strategic investments in electricity efficiency and space heating efficiency since the year 2000. Under the leadership of its chairman, Frank Dietz, the condominium has invested $4,480 in electricity efficiency investments – primarily energy efficient lighting. In turn its gross savings between 2000 and 2009 were $28,061. The condominium investments to reduce natural gas use totalled $3,178 and have netted gross savings between 2000 and 2009 of $31,333. The condominium has 41 residents. The Board has been able to keep condo fees unchanged for the past eight years. Mr. Dietz has generously donated his labour to the project free of charge, so this must be taken account of when considering the numbers for up-front capital costs. (Source: Visit with condo chair Frank Dietz, September 2010)

17 Telephone conversation by Peter Prebble, MLA with SaskHousing staff in September 2007.

18 Presentations to Peter Prebble, MLA in the summer of 2006 by Lloyd Kuczek, Division Manager, Consumer Marketing and Sales, Power Smart, Manitoba Hydro; Lois Morrison, Manager of Marketing Programs, Manitoba Hydro; Rhonda Orr, Manager of Government Relations and Current Issues Co-ordination, Manitoba Hydro; Gerry Rose, Vice President of Customer Service and Marketing, Power Smart, Manitoba Hydro; Rick Patrick, Vice President of Environment and Regulatory Affairs, SaskPower and Demand Side Management Unit staff, SaskPower.

19 California Public Utilities Commission and California Energy Commission. "Energy Efficiency – California's Highest Priority Resource: Lowering Energy Costs, Promoting Economic Growth and Protecting the Environment", August 2006, pp. 3-4.

20 SaskPower. "SaskPower Annual Report 2010: The changing energy landscape", p. 18. Refer to section titled 'New Capacity'.

21 Saskatchewan Power Corporation (2007:Sep: 17): "SaskPower Eneraction will help customers save money and the environment", Government of Saskatchewan news release.

Saskatchewan Power Corporation (2009): 2008 Environment Report. Available at *http://www.saskpower.com/environment/report/2008/pdf/2009complete.pdf* (last accessed 2010:Mar:11)

SaskPower. "SaskPower Annual Report 2010: The changing energy landscape", p. 25. Refer to section titled 'SaskPower Eneraction'.

22 Roger Peters, Stephen Hall and Mark Winfield. "A Quick Start Energy-Efficiency Strategy for Ontario". (Ottawa, Ontario: The Pembina Institute), April 2006, p. 8.

23 Meeting by Peter Prebble in July 2007 with Blair Hamilton, President, Efficiency Vermont and Scudder Parker, Senior Project Manager, Efficiency Vermont.

24 Effiiciency Vermont. "2008 Annual Report", October 1, 2009, p. i.

25 Correspondence to Peter Prebble from Cathy Holtslander, June 16, 2011.

26 Peter Prebble, Legislative Secretary for Renewable Energy Development and Conservation. *A First Report On Making Saskatchewan A Canadian Leader In Energy Conservation And Renewable Energy Development*, December 2006, p. 43.

27 It should be noted that both the above mentioned examples employ district heating. District heating would require residents of a community to shift to a water-based central heating system in their buildings. A central distribution system would be established in the community to transport hot water to every building in town. One exciting component of a district heating system is that it readily lends itself to the use of one or more renewable energy sources to heat the hot water, thus making fossil fuels unnecessary.

28 Presentation by Marcus Braunm, Office of the Mayor, Town of Crailsheim, Germany and Michaela Schoph, Renewable Energy Specialist and Project Leader, Town of Crailsheim to representatives of the Government of Saskatchewan, February 2007.

29 C40 Cities web site: "Renewables, Rizhao, China: An extensive solar program in China". (*www.c40cities.org/bestpractices/renewables/rizhao_solar.jsp*)

30 Presentation by Dr. Erwin Knapek, Mayor of Unterhacing, Germany to representatives of the Government of Saskatchewan, February 2007. Dr. Knapek led the installation of a geothermal system for electricity generation and space heating in the town of Unterhacing. The system was originally envisaged for space heating purposes, but the underground hot water source, when accessed by drilling, offered high enough temperature steam that it could also be used to drive a steam turbine and generate electricity. In southern Saskatchewan we are unlikely to have a hot water resource with sufficiently high temperatures to generate electricity, but our hot water resource should be well suited for space heating purposes.

31 C40 Cities web site. "Renewables, Växjö, Sweden: Växjö is halfway to becoming fossil fuel free". (*www.c40cities.org/bestpractices/renewables/Växjö_fossilfuel.jsp*, accessed in 2008)

32 INFORSE Europe. "Samsø 100% Renewable Energy Island, Denmark" (*http://casestudies.inforse.org/node/6*)

33 Presentation by Preben Maegaard, Danish Folkcenter for Renewable Energy and President of the World Wind Energy Association from 2001-2005. 7th World Wind Energy Conference 2008, Kingston, Ontario, June 26, 2008.

34 SaskPower. *SaskPower Sustainability Report 2009*, p. 5.

SaskPower. "SaskPower Annual Report 2010: The changing energy landscape", p. 18. Refer to section entitled 'New Capacity'.

35 SaskPower. "Red Lily Wind Project Now In Service", February 28, 2011 news release. The Red Lily Wind Project has 26.4 MW of generating capacity.

36 SaskPower. *SaskPower Sustainability Report 2009*, p. 16. Refer to chart titled '2009 electricity supplied – 19,864 GWh' .

SaskPower. *SaskPower Environment Report 2008*, p. 21. In 2008 hydro met 20 percent of the electricity supplied in Saskatchewan.

37 In 2009 electricity imports constituted two percent of electricity supplied in Saskatchewan. (SaskPower, *SaskPower Sustainability Report 2009*, p. 16)

38 A mid-west U.S. wind study demonstrated that if wind turbines are sufficiently dispersed (over an area of approximately 850 kilometres by 850 kilometres) they can effectively provide some base load power with the same degree of reliability as a coal fired generating station. (Mark Jacobson and Cristina Archer. *Journal of Applied Meteorology and Climatology*, November 2007)

39 By way of example, the 63 MW Nine Canyon Wind Farm in Washington state has its output successfully coordinated with an existing 65 MW hydro facility at an extra cost of 0.09 cents per kilowatt hour. (Roger Peters, Professional Engineer and retired energy analyst with Pembina Institute. "Meeting Our Energy Needs With Renewable Energy." A Presentation at the University of Saskatchewan, February 24, 2009.)

40 Cinta Puxley, "Manitoba Hydro signs $4 billion power deal". The Globe and Mail, May 25, 2011. This article reports on an agreement by Manitoba Hydro to sell 250 MW of hydro to Minnesota from 2020 to 2035. Under the agreement, Manitoba will also import wind energy from Minnesota. Manitoba will in effect store the wind power, using its system "as a rechargeable battery".

41 Cinta Puxley, "Manitoba Hydro signs $4 billion power deal". *The Globe and Mail*, May 25, 2011. Manitoba Hydro exports about 2,000 MW of the electricity it produces. Deals signed in May 2011 with Minnesota and Wisconsin will increase that by another 20%. Manitoba plans to proceed with a new 695MW generating station to help meet the export obligations under the newly signed Minnesota and Wisconsin agreements. (Refer to Manitoba Hydro website for more details.)

Manitoba Hydro Web Site. "Power Sale Arrangement With Wisconsin Public Service", *http://www.hydro.mb.ca./corporate/electricity_exports/wisconsin.shtml* Manitoba currently has an agreement with Wisconsin Public Service for the sale of 100 MW of electricity over the period from 2021-2027. Negotiations are continuing to expand that sales agreement to 500 MW.

42 *The Canadian Press*. "Sask., Man., to study inter-provincial energy sharing", February 2, 2010.

Current transmission capacity between Saskatchewan and Manitoba is 105 MW. (Larry Kusch, "Hydro to power up Saskatchewan?" Winnipeg Free Press, January 11, 2011.)

43 REN21. 2010. *Renewables 2010 Global Status Report* (Paris: REN 21 Secretariat), September 2010, p. 37.

44 Dsireusa.org. "California: Incentives/Policies for Renewables & Efficiency." (*http://www.dsireusa.org/icentives/incentive.cfm?Incentive_Code-CA25R&state=CA&...*) Accessed on January 10, 2011.

45 Oregon Department of Energy. "Summary of Oregon's Renewable Portfolio Standard", October 7, 2007. Refer to Table 1: Summary of RPS Targets and Timelines".

46 Dsireusa.org (Database of State Incentives for Renewables and Efficiency) Refer to RPS Policies.

47 SaskPower. "Environmentally Preferred Technologies – SaskPower", SaskPower web site. (*http://www.saskpower.com/sustainable_growth/generate_move_power/environmentally...*) Accessed on January 10, 2011.

48 Saskatchewan Research Council. "Net Metering". Saskatchewan Research Council web site. (*http://www.src.sk.ca/html/research_technology/energy_conservation/net_metering/index...*) Accessed on January 10, 2011.

49 Workshop on net metering at February 2011 Alternative Energy Conference, Moose Jaw, Saskatchewan.

50 Saskatchewan Research Council. "Net Metering". Saskatchewan Research Council web site. (*http://www.src.sk.ca/html/research_technology/energy_conservation/net_metering/index...*) Accessed on May 28, 2011.

51 Nova Scotia Power. 'Net Metering' Refer to the section entitled 'Enhancements'. (*http://www.nspower.ca/en/home/environment/renewableenergy/netmetering/default.print*) Accessed May 29, 2011.

52 Saskatchewan Research Council. "Net Metering". Saskatchewan Research Council web site. (*http://www.src.sk.ca/html/research_technology/energy_conservation/net_metering/index*...) Accessed on January 10, 2011.

53 Feed in tariffs have delivered over 75% of solar PV installations worldwide and over 90% of farm biogas worldwide. (Paul Gipe, "Ontario's Feed-in Tariffs: Setting the Standard in North America", 2011, slide #5 For Further information please refer to Paul Gipe, wind-works.org)

54 Tyler Hamilton. "Ontario's FIT program a success after one year", *The Toronto Star*, September 27, 2010.

55 Paul Gipe. "It's Official: Ontario Third In North American 2009 Solar PV Capacity – Now In a Race for Second with New Jersey", August 23, 2010 (*pgipe@igc.org*)

56 Paul Gipe, "Ontario Leaps to Second in North American Solar PV for 2010", January 21, 2011. The installation figures are expressed in Direct Current.

57 Paul Gipe. "Nova Scotia's Proposed CommFIT Tariffs Circulated", January 7, 2011 (*http://www.wind-workds.org/FeedLaws/Canada/NovaScotiasProposedComFITTariffsCirc*...)

Tim Bousquet, "Feed – In Tariff Troubles", The Coast, April 28, 2011. (*http://www.thecoast.ca/gyrbase/fee-in-tariff-troubles/Content?oid=2439820&mode=print*) Bousquet notes that projects must have majority ownership of a 'community organization'. Five kinds of community organizations are allowed: municipalities, universities, First Nations, co-operatives and Community Economic Development Investment Funds.

58 The reference for 15% of the electricity in Ontario's Feed-In-Tariff Program coming from community power is from the following source: Paul Gipe. 'Ontario's Feed-in Tariffs: Setting the Standard in North America', June 6, 2011. Refer to 'Ontario Program Status', slide 23. (Accessed June 20, 2011.) 400 MW in contracts has been allocated in the 'community and aboriginal' category. Paul Gipe notes the 15% figure is the largest in North America to date.

59 This type of ownership structure would still allow for a minority share of private sector investment in many projects, to the degree deemed desirable by community stakeholders. Such investment partnerships will be particularly desirable where there is a need to acquire technological expertise from interested companies in the renewable energy industry.

60 SaskPower. "Powering A Sustainable Energy Future", January 29, 2010, Appendix A.

61 Mark Bigland-Pritchard, "Transforming Saskatchewan's Electrical Future – Part Two: Using Electricity More Efficiently", (Canadian Centre for Policy Alternatives, November 2010), p. 9.

62 Ibid, p. 10

63 SaskPower International web site. Refer to "Power Projects – Cory Cogeneration Station" (*www.saskpowerinternational.com/cory.shtml*) Accessed April 9, 2008.

64 This presumes that the four oldest coal fired units at Boundary Dam would be shut down. They were commissioned in 1959, 1960, 1970 and 1973. (A 1969 Unit at the plant – Unit 3 – is currently being retrofitted and equipped with Carbon Capture and Storage.) In addition to the renewable energy projects and conservation initiatives discussed in this paper, it is assumed that SaskPower's heat recovery projects and already committed natural gas projects come on line as scheduled. Heat recovery projects are particularly desirable because of their very low greenhouse emissions.

65 SaskPower. "SaskPower Sustainability Report 2009, pp. 5 and 16. While coal accounted for only 44% of available generating capacity in 2009, it accounted for 62% of electricity supplied in 2009.

66 SaskPower is currently projecting Saskatchewan's electricity system 'peak' to grow from 3231 MW in 2009 to 4,318 MW by 2019. (SaskPower. "Powering A Sustainable Energy Future", January 29, 2010, p. 7.) This presumes a weaker conservation effort than being proposed in this paper.

Any phase out of coal fired power plants will require a carefully developed plan, mutually agreed to by SaskPower and unionized employees, to ensure that all impacted workers receive fair compensation and opportunities for alternative employment. Since phase out is likely to occur over the course of two decades, there would be considerable potential for regularly scheduled retirement and early retirement to meet the needs of a great many workers. Employees should also be provided with opportunities for retraining in renewable energy technologies and with opportunities to transfer to other occupations within SaskPower or the larger public sector.

67 G. Miller Tyler Jr. and Dave Hackett, *Living in the Environment*, (Thomson Nelson: 2007), p. 372.

68 Government of Ontario: 'Phasing Out Coal Power in Ontario', October 1, 2010. (*http://www.news.ontario.ca/mei/en/2010/10/phasing-out-coal-power-in-ontario.html*) Accessed June 20, 2011.

69 Ibid.

70 Richard Conniff. "The Greenhouse Gas That Nobody Knew", Yale Environment 360 Web Site, November 13, 2008.

ICIS Chemical Business. "Solar drives electronic gases", March 20, 2008.

(*http://www.icis.com/Articles/2008/03/24/9109896/strong-photovoltaic-and-electronics-se...*) Accessed January 22, 2011.

71 Ray F. Weiss, Jens Muhle, Peter K. Salameh and Christina M. Harth. "Nitrogen trifluoride in the global atmosphere". Geoophysical Research Letters, Vol. 35, October 31, 2008, Abstract.

72 Ibid. Weis et al estimate that NF3 is rising at a rate of about 11% per year.

73 Richard Conniff, ibid.

74 Mark Bigland-Pritchard, "Transforming Saskatchewan's Electrical Future – Part Three: The Potential for Wind and Solar Power, (Canadian Centre for Policy Alternatives: December 2010), p.11.

75 Ibid, p. 16.

76 Ibid, p. 17.

77 Mark Bigland-Pritchard, "Transforming Saskatchewan's Electrical Future – Part Four: Biomass Power and Dispatchable Options" (Canadian Centre for Policy Alternatives, June 2010). Refer to 'Conclusions and Recommendations'.

78 Ibid.

79 Correspondence with recommendations from Cathy Holtslander, June 22, 2011.

80 Ibid, p. 15.

81 Mark Bigland-Pritchard, "Transforming Saskatchewan's Electrical Future – Part Three: The Potential for Wind and Solar Power", (Canadian Centre for Policy Alternatives: December 2010), p.17.

82 Martin Mittelstaedt. "Green power at 'clear tipping point'. *The Globe and Mail*, July 15, 2010, p. B7.

83 Intergovernmental Panel on Climate Change. "Potential of Renewable Energy Outlined in Report by the Intergovernmental Panel on Climate Change", May 9, 2011 press release, p. 3.

84 Ibid, p. 2.

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85 B. Bates, Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., *2008: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change*, IPCC Secretariat, Geneva, 2008, pp. 3, 15-16.

The authors state: "The frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) has increased over most areas (likely)."

86 Thomas Karl, Gerald Meehl, Christopher Miller, Susan Hassol, Anne Maple and William Murray. *Weather and Climate Extremes in a Changing Climate: Regions of Focus – North America, Hawaii, Caribbean and U.S. Pacific Islands*. (The US Climate Science Program and the Subcommittee on Global Change Research, June 2008), p. 4. Refer to 'Precipitation Extremes'.

87 B. Bates, Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., *2008: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change*, ibid, p. 16.

88 World Water Assessment Programme, 2009, *The United Nations World Water Development Report 3: Water In A Changing World*. Paris: UNESCO, and London: Earthscan. Refer to the fourth page of Chapter 12: 'Evolving Hazards and Emerging Opportunities'. Chapter Author: Bruce Stewart. Coordinator: Andras Szollosi-Nagy (UNESCO). Facilitator: Denis Hughes.

89 B. Bates, Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 2008: *Climate Change and Water: Technical Paper of the Intergovernmental Panel on Climate Change*, IPCC Secretariat, Geneva, 2008, p.3.

90 Cumbria Intelligence Observatory. "Cumbria Floods November 2009 – Overview and Meterorological Circumstances". (*http://www.cumbriaobservatory.org.uk/AboutCumbria/Floods/November2009.asp*)

91 GCCapitalIdeas.com "Typhoon Kesana", September 28, 2010. (*http://www.gccapitalideas.com/2009/09/28/typhoon-ketsana/*)

92 Australian Broadcasting Corporation. "PM says deadly floods are Poland's worst ever", May 23, 2010. (*http://www.abc.net.au/news/stories/2010/05/23/2906917.htm*).

Poland was hit by a second round of flooding in August 2010. That flooding extended into the Czech Republic where 124 villages were flooded. (Lenka Ponikelska. "Flooding in Central Europe eases after weekend torrents leave nine dead", August 9, 2010. (*http://www.bloomberg.com/news2010-08-09/flooding-in-central-europe-eases-after-weekend*)

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94 Michelle Yonetani. *Displacement due to natural hazard-induced disasters: Global estimates for 2009 and 2010* (Internal Displacement Monitoring Centre and Norwegian Refugee Council, June 2011), p. 13, Table 3.

95 Christopher Boden. "Asia lashed by floods and landslide", *The Globe and Mail*, August 9, 2010, p. A7.

96 Michelle Yonetani. *Displacement due to natural hazard-induced disasters: Global estimates for 2009 and 2010*, ibid. p. 13, Table 3.

97 Ibid.

98 *The Globe and Mail*, January 13, 2011.

99 "Australia floods demonstrate rising cost of damage in the face of "new normal". Press release issued by International Strategy for Disaster Reduction (ISDR), Geneva, December 29, 2010.

The Associated Press. "200,000 people affected by flooding in Australia", December 30, 2010.

Craig Offman (ed.) "Folio: Floods in Australia". *The Globe and Mail*, January 13, 2011, p. A8.

The Associated Press. "Australians warned not to return to flooded homes", January 13, 2011.

The Star Phoenix. "Brisbane begins massive flood clean-up", January 15, 2011.

100 Internal Displacement Monitoring Centre and Norwegian Refugee Council. "42 million displaced by sudden natural disasters in 2010 – Report", June 6, 2011 Press Release (Geneva and Oslo).

101 Internal Displacement Monitoring Centre and Norwegian Refugee Council. "42 million displaced by sudden natural disasters in 2010 – Report", June 6, 2011 Press Release (Geneva and Oslo).

Michelle Yonetani. *Displacement due to natural hazard-induced disasters: Global estimates for 2009 and 2010*, ibid. p. 11. Refer to 'Scale of global displacement by type of disaster'.

102 Minister of Finance. Public Accounts: Details of Revenue and Expense for the fiscal years 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010. (Published by the Government of Saskatchewan, Regina, Saskatchewan.) Refer to Volume 2 of the Public Accounts for each fiscal year. Then refer to the line item: 'Provincial Disaster Assistance Program'. This is listed under the 'Public Safety' subvote. One of the functions of the Public Accounts is to provide a final expenditure total on programs delivered by each Ministry in a given fiscal year.

To obtain an estimate for the current fiscal year the following information was used:

Minister of Finance. Saskatchewan Provincial Budget: 2010-2011 – Estimates, p. 43.

Minister of Finance. Saskatchewan Provincial Budget: 2010-11 – Supplementary Estimates, p. 12.

In the 2010-2011 fiscal year the Public Safety Branch budgeted $550,000 for PDAP as noted in the Estimates. In the course of the first six months of the fiscal year, the Public Safety Branch had to increase spending on PDAP by an additional $25,051,000 as noted on page 12 of the November 2010 supplementary estimates.

103 Saskatchewan News Network. "Province still accepting disaster assistance claims". The Star Phoenix, December 23, 2010, p. A8.

104 CBC News. "North Battleford declares storm emergency", July 22, 2010.

Rory MacLean. "Flood clean-up in North Battleford", *The Star Phoenix*, July 23, 2010. North Battleford was hit by 67 mm of rain. 100 homes reported flooding. Fourteen families – a total of 45 people – were displaced.

CBC News. "Storm-ravaged Sask. gets provincial aid", July 3, 2010. This story reports that Saskatoon received 85mm of rain in three hours, overwhelming its infrastructure. There was significant flooding in the neighbourhoods of Confederation Park, Westview and Massey Place.

The Globe and Mail. "Flooding prompts evacuations in Yorkton, Sask.", July 2, 2010. The story reports that downtown streets were under 'waist deep water'.

105 Cassandra Kyle. "Prairie farmers get $450 million to recover from flooding", *The Star Phoenix*, July 8, 2010. Farmers received $30 per unseeded acre. Saskatchewan farmers received $360 million. Ottawa funded 60% of the program with the Government of Saskatchewan funding the rest.

106 National Oceanic and Atmospheric Administration. "NOAA: 2010 Tied For Warmest Year On Record", January 12, 2011. (*http://www.noaanews.noaa.gov/stories2011/20110112_globalstats.html*)

107 World Meteorological Organization. "2010 equals record for world's warmest year", Press Release No. 906 (Geneva, January 20, 2011).

108 Ibid.

109 Environment Canada. "Climate Trends and Variations Bulletin – Annual 2010" , p. 1. (*http://ec.g..ca/adsc-cmda/default.asp?lang+en&n+77842065-1*)

110 Damien McElroy. "Russian heat wave kills 5,000 as fires rage out of control". The Telegraph, August 6, 2010.

111 Met Office: Hadley Centre. *Evidence: The State of the Climate* (Met Office: United Kingdom, 2010), p. 18.

112 John Vadal. "2010: probably the hottest year ever recorded". *The Guardian*, December 14, 2010.

113 S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor and H.L. Miller (eds), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2007), p. 13.

Under the highest greenhouse gas emission scenario forecast by IPCC for the period 2090-99 relative to 1980-99 global average temperatures are projected to rise between 2.4 and 6.4 degrees C. (Ibid., p. 13, Table SPM3) In the years since these IPCC forecasts were made, global greenhouse gas pollution levels have in fact been following the highest of the IPCC emission forecasts. If this is allowed to continue many scientists emphasize that the consequences of global temperatures at the higher end of temperature projections would be catastrophic. (E.g. S.H. Schneider, "Climate Change: Do We Know Enough For Policy Action", *Science and Engineering Ethics 12*, 2006, p. 608.) These concerns are echoed by Nicholas Stern who stresses that a 5-6°C average global temperature increase on our planet would be equivalent to the temperature difference between the last Ice Age and today. (Nicholas Stern, *The Economics of Climate Change*, Cambridge University Press, United Kingdom, 2007, p. 8.)

114 United Nations. "Drylands Matter and Why", p. 1. This press kit was prepared as part of the launch of the 'United Nations Decade for Deserts and the Fight Against Desertification'.

115 Geoffrey Lean and Kathy Marks. "Parched: Australia faces collapse as climate change kicks in". The Independent, February 1, 2009. Lean and Marks report that parts of southern Australia have faced an unprecedented 12 year drought. At the time of writing, Adelaide's temperature had exceeded 45°C.

BBC News Web Site. "California in drought emergency", February 28, 2009. BBC News reported that three years of below average rainfall resulted in many fields in California being left fallow and thousands of farm workers being laid off.

116 Geoffrey York. "On the move in a warming world". *The Globe and Mail*, December 18, 2010, p. F6.

117 Bruce Stewart et al, "Evolving hazards and emerging opportunities" in World Water Assessment Programme, *The United Nations Water Development Report 3: Water in a Changing World* (Paris: UNESCO and London: Earthscan, 2009), Chapter 12. Refer to the section entitled 'Low Flows and Droughts'.

118 *IPCC 2007, Summary for Policy Makers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group 2 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, New York, 2007), p. 13. Refer to the subheading 'Africa'.

119 Statement of Dr. K.K. Pachauri, Chairman, IPCC to the United Nations Conference on Climate Change held in Copenhagen, Denmark in December 2009.

120 U.S. National Science and Technology Council. S*cientific Assessment of the Effects of Global Change on the United States*. A Report of the Committee on Environment and Natural Resources, National Science and Technology Council, May 2008, p. 10.

121 United Nations. "Drylands Matter and Why", p. 2. This press kit was prepared as part of the launch of the 'United Nations Decade for Deserts and the Fight Against Desertification'. Estimates of the numbers of persons who could be displaced as a result of water stress range from 24 million to as much as 700 million people.

122 Dave Sauchyn, Elaine Barrow, X. Fang, Norm Henderson, Mark Johnston, John Pomeroy, Jeff Thorpe, Elaine Wheaton, B. Williams. *Saskatchewan's Natural Capital in a Changing Climate: An Assessment of Impacts and Adaptation*. (PARC, Regina, 2009), Summary Report, p. 6.

123 Dave Sauchyn, Elaine Barrow, X. Fang, Norm Henderson, Mark Johnston, John Pomeroy, Jeff Thorpe, Elaine Wheaton, B. Williams. *Saskatchewan's Natural Capital in a Changing Climate: An Assessment of Impacts and Adaptation*. (PARC, Regina, 2009), Summary Report, p. 4.

124 Andre Prefontaine, Editor in Chief. "A Changing Climate" (map of Canada), The Royal Canadian Geographical Society and the National Round Table on the Environment and the Economy, 2010. Refer to 'Impacts on Prairies'.

Examples of other impacts identified by the authors include increased water scarcity, stressed aquatic habitats, more pests and diseases and more difficulty accessing northern communities via winter roads.

125 Ibid.

126 I. Allison, N. Bindoff, R. Bindschadler, P. Cox, N. de Noblet, M. England, J. Francis, N. Gruber, A. Haywood, D. Karoly, G. Kaser, C Le Quere, T. Lenton, M. Mann, B. McNeil, A. Pitman, S. Rahmstart, E. Rignot, H. Schelnhuber, S. Schneider, S. Sherwood, R. Somerville, K. Steffen, E. Steig, M. Visbeck, A. Weaver. *The Copenhagen Diagnosis: Updating the World on the Latest Climate Science* (Sydney: The University of New South Wales Climate Change Research, 2009), p. 39.

L. Bernstein, et al. *IPCC 2007: Climate Change 2007 Synthesis Report, Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, 2007), p. 2.

To underline the change that is occurring, the IPCC reported sea level rise at 3.1mm per year in their 2007 publication. A little over two years later, many of the scientists involved in the IPCC process published *The Copenhagen Diagnosis* and reported sea level rise at 3.4 mm per year.

127 I. Allison, et. al, *The Copenhagen Diagnosis: Updating the World on the Latest Climate Science*, ibid., p. 39.

128 S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor and H.L. Miller (eds), *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge: Cambridge University Press, 2007), Table SPM.3: 'Projected global average surface warming and sea level rise at the end of the 21st century'.

129 Australian On-Line Coastal Information. "Sea level rise maps: South East Queensland (including Brisbane and the Gold Coast)", *http://www.ozcoasts.org.au/climate/sd_visual.jsp*

Another example is the United Kingdom Climate Projections '09 which forecast a range of sea level increases up to 76cm by 2095. (Refer to: The Institution of Civil Engineers. "Facing Up To Rising Sea Levels: Retreat? Defend? Attack? – The Future of our Coastal and Estuarine Cities", p. 3.)

130 Ibid.

131 "Ice Loss from Canadian Glaciers Documented by Trent Professor's Research: Glaciers in Canada's north now major players in sea-level rise", April 20, 2011. (*http://www.trentu.ac/newsDetails.aspx?Channel=%2FChannels%2FAdmissions+Content* Accessed May 25, 2011)

Alex Gardner, Geir Moholdt, Bert Wouters, Gabriel Wolken, David Burgess, Martin Sharp, J. Grahma Cogley, Carsten Braun and Claude Labine, "Sharply increased mass loss from glaciers and ice caps in the Canadian Arctic Archipelago" in *Nature* 10089, 2011.

132 World Glacier Monitoring Service. "Glacier mass balance data 2008 and 2009", *http://www.wgms.ch/mbb/sum09.html* (accessed June 12, 2011) Refer to the subtitle 'Summary of the balance years'.

133 Juliette Jowit. "World's glaciers continue to melt at historic rates", *The Guardian*, January 25, 2010.

134 "Press Conference By Alliance Of Small Island States Addressing Climate Change" (Department of Public Information, United Nations, New York, February 12, 2008).

135 Randeep Ramesh. "Paradise almost lost: Maldives seek to buy a new homeland", *The Guardian*, November 10, 2008.

136 Margaret Munroe, "Northern communities Brace For Disastrous Melt". *The Star Phoenix*: October 7, 2006, p. E2.

137 Patrick Barkham, "Waves of Destruction". *The Guardian* (London, April 17, 2008).

138 "Rising sea sinks 2 Sundarbans islands in India", *The Daily Star*, December 22, 2006, p. 1.

139 R. Nicholls, P. Wong, V. Burkett, J. Codignotto, J. Hay, R. McLean, S. Ragoonaden and C. Woodroffe, 'Coastal Systems and Low Lying Areas' in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group 2 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M. Parry, O. Canziani, J. Palutikof, P. van der Linden and C. Hanson (eds), (Cambridge University Press, Cambridge, U.K.), p. 325. The authors emphasize that the combination of increases in average sea levels combined with more intense storm systems will create changes in 'extreme sea levels' that will in turn pose a danger to communities.

140 Ibid, p. 326.

141 Stern, Nicholas, *The Economics of Climate Change*, ibid., p. 20. In his report to the government of the United Kingdom, Stern emphasizes that if the Greenland or West Antarctic Ice Sheets melt irreversibly, sea level rise could ultimately be in the range of 5-12 metres over several centuries.

142 Larry Elliot and Mark Tran. "UN report warns of threat to human progress from climate change". *The Guardian*, November 4, 2010.

143 *Copenhagen Accord*. Adopted December 18, 2009. The reference to the 2°C goal can be found in Article 1.

144 M. Parry, O. Canziani, J. Palutikof, P. van der Linden and C. Hanson (eds), IPCC 2007, 'Summary for Policy Makers' in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group 2 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. (Cambridge University Press, Cambridge, U.K.), p. 16.

145 Nicholas Stern. *The Economics of Climate Change*. (Cambridge University Press, United Kingdom, 2007), p. 220.

Jowit, Juliette and Patrick Wintour. "Cost of Tackling Global Climate Change Has Doubled Warns Stern". *The Guardian*, June 26, 2008. Stern's major climate review for the UK government, backed by the advice of a large number of climate scientists, had originally estimated the maximum allowable CO_2e levels at 550 parts per million. The review had made it clear there were large risks of exceeding a global average temperature increase of 2°C at this level. In June 2008 in a major speech at the opening of Britain's Carbon Rating Agency, Stern revised this upper figure downwards to 500 parts per million CO_2e. He observed that climate change is occurring faster than previously thought.

'2007 Bali Declaration By Scientists'. Climate Change Research Centre Web Site,

University of New South Wales, Sydney, Australia. (Accessed on February 10, 2009) The declaration was signed by over 200 well respected scientists who urged that greenhouse gas concentrations need to be stabilized at a level below 450 parts per million CO_2e.

It should be noted that some climate scientists are of the view that carbon dioxide concentrations in the atmosphere should not be allowed to exceed 350 parts per million. (When other greenhouse gases monitored by the UN are included, this would place CO_2e at just over 400 ppm.) Most prominent among them is Dr. James Hansen, a pioneer in climate science and one of the first scientists to warn the U.S. government of the grave risks associated with climate change. Current carbon dioxide concentrations are already over 390 parts per million, so these scientists are of the view that we have already exceeded the maximum allowable CO_2 concentrations in the atmosphere. (For further information refer to *www.350.org*)

In summary, opinion on the maximum allowable level of CO_2e ranges from 400 ppm to 500ppm. For the purposes of setting public policy over the next 10-20 years, whichever maximum level proves to be most accurate, the essence of the message is similar because under every one of these scenarios we have very little time left to act in order to avert dangerous climate change. Moreover, in each of these scenarios deep greenhouse gas emission cuts are needed as quickly as possible.

146 David Adam, "Global warming monitoring needs to find 'missing heat' say scientists". *The Guardian*, April 15, 2010.

147 European Environment Agency. "Atmospheric greenhouse gas concentrations (CSI 013) – Assessment", November 2010, p. 2 (*http://www.eea.europa.eu/data-and-maps/indicators/atmospheric-greenhouse-gas-concent*...) Accessed: November 8, 2010.

148 Another approach to answering this question is to calculate the number of tonnes of carbon dioxide that humanity can emit between now and 2050 in order to hold global average temperature below 2°C. The German government's climate change protection adviser, Hans Joachim Schellnhuber has done this and calculated it at 750 billion tonnes of CO2. In a world with 6.7 billion people, this works out to 110 tonnes per person – the total amount per person that can be emitted over the next 40 years. (Source: *The Guardian*. "Schellnhuber: developed countries are 'carbon insolvent', September 10, 2009)

If the rate of greenhouse gas emissions in Saskatchewan (71 tonnes per person) was applied worldwide, this 110 tonnes per person total would be exhausted in two years. At the rate of emissions in Canada and the United States (approximately 20 tonnes per person) this total would be exceeded within 6 years. At the current per capita rate of global emissions, I estimate the total will be reached in less than 20 years, unless emissions are sharply curbed.

149 Richard Betts, Mathew Bollins, Deborah Hemming, Chris Jones, Jason Lowe and Michael Sanderson. "When could global Warming reach 4°C?". *Philosophical Transactions of the Royal Society*. (United Kingdom, 2011) 369, p 67-84.

150 The reference for the lifetime of nitrous oxide in the atmosphere is: Tim Flannery. *The Weather Makers: How We Are Changing The Climate And What It Means For Life On Earth*. (Harper Collins Publishers Ltd., 2005), pp. 30-31.

151 S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor and H.L. Millers (eds). *IPCC, 2007: The Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, UK and New York, USA, 2007), p. 25.

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152 The scientists targeted in the so-called "climategate" affair have been vindicated by five different independent official enquiries in the UK and the USA.

153 The transcript for this video may be found at *http://www.wakeupfreakout.org*.

154 Hansen J E (2008), Target atmospheric CO_2: Where should humanity aim?, Open Atmos Sci J, vol.2, pp217-231. Available online at *http://arxiv.org/abs/0804.1126* (main article) and *http://arxiv.org/abs/0804.1135* (supporting material). Further scientific background is available in two other Hansen papers:

Hansen J E and Sato M (2009), Paleoclimate implications for human-made climate change. Available online at *http://arxiv.org/abs/1105.0968*

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End Notes for Graphs

Atmospheric concentrations of important long lived greenhouse gases over time (page 22)
Atmospheric concentrations of important long-lived greenhouse gases over the last 2,000 years. Increases since about 1750 are attributed to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion air molecules, respectively, in an atmospheric sample. Source: FAQ 2.1, Figure 1 in Climate Change 2007: The Physical Science Basis, Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Global and continental temperature change over time (page 25)
Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906 to 2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901 to 1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5% to 95% range for 19 simulations from 5 climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5% to 95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. Source: Figure SPM.4 in: Climate Change 2007: The Physical Science Basis, Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Examples of current vulnerabilities of freshwater resources in the world (page 28)
Examples of current vulnerabilities of freshwater resources and their management; in the background, a water stress map based on Alcamo et al. (2003a). Source: Figure 3.2 in Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group 2 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.