Saskatchewan Legislature:

Standing Committee on Crown and Central Agencies

Public Hearing on Electricity Options

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Saskatchewan's Electricity Future: Sustainability is Achievable

[slide 1]

the context

Saskatchewan, like other jurisdictions, faces a number of unprecedented challenges as it chooses its electricity options for the future:

[slide 2]

1. Climate change. The evidence for anthropogenic climate change is overwhelming, and Saskatchewan, with greenhouse gas emissions of 72 tonnes per person per year (7 times that of typical European countries with a similar standard of living), is a major contributor. There is a particularly urgent global need to avoid the 2ºC threshold and the "tipping points" associated with it.
2. Secondly, the international response to the threat of climate change will most likely include the introduction of carbon pricing. While I am not competent to comment on the likely rate per tonne of carbon dioxide, it will be a significant cost, and rates are likely to increase as time goes on.
3. Like many other jurisdictions, Saskatchewan has ageing electrical infrastructure, and will need to invest very soon in new plant and transmission lines.
4. Non-renewable energy resources are being depleted. We may or may not have already passed "peak oil"; peak gas, peak uranium and peak coal will all follow in a matter of decades.

[slide 3]

A graph of fossil fuel consumption against time puts our situation into context. Until a couple of centuries ago, humanity relied on energy derived ultimately from the sun. When fossil and nuclear fuels are exhausted, we will again be dependent on the sun – i.e. on the renewable options.. We are currently somewhere near the top of a historic blip. In this context, why wait to develop renewable technologies?

[slide 4]

After all, the energy available from the sun is vast.

[slide 5]

Sustainable Power for Saskatchewan

To meet these challenges, Saskatchewan needs to make a decisive shift to develop a fully sustainable power mix.

[slide 6]

Sustainable development, as defined by the UN's Brundtland Commission[1] in 1987, is:

"meeting the needs of the present without compromising the ability of future generations to meet their own needs"

Neither fossil fuels nor nuclear power can meet this description. That does not mean that the other options – the renewables – are necessarily sustainable in a given context:: it is possible to develop them in either a sustainable or a non-sustainable way. We should choose to develop them in a way which is sustainable environmentally, financially and socially.

[slide 7]

A move towards sustainable electricity will require a transition period, in which quick-to-deploy, relatively low-GHG technologies are used. Ultimately, however, these will be replaced by options with even lower

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1 World Commission on Environment and Development (chair: Gro Harlem Brundtland) (1987), Our Common Future, Oxford University Press

environmental impact, including zero or negative net GHG emissions.

[slides 8 to 13]

That this type of path is viable is shown by a variety of studies worldwide. In Germany, the federal government has committed itself to increasing the proportion of its electricity generated from renewables to 30% by 2020 and 50% by 2030[2], and has expressed hope of reaching 100% by 2050. A detailed study in Britain by the Centre for Alternative Technology and the University of East London has set out a path for achieving 100% electricity from renewables there[3]. Another recent British study used state-of-the-art energy hourly dynamic energy modelling techniques to demonstrate that at least 95% of Britain's electricity could readily be supplied by renewables[4]. In the USA, the new chair of the Federal Electricity Regulatory Commission, Jon Wellinghoff, has said that "*no new nuclear or coal plants may ever be needed in the United States*" and that "*renewables like wind, solar and biomass will provide enough energy to meet baseload capacity and future energy demands*".[5] That Mr Wellinghoff should be saying this is significant: his role is to ensure security of supply of electricity, and he cannot make such statements lightly. Recent reports by the Pembina Institute have demonstrated, using very conservative assumptions, that both Ontario[6] and Alberta[7] could move a very long way down the road to 100% renewables power provision by 2030. Saskatchewan has excellent wind and solar resources, substantial quantities of agricultural and forestry residue suitable for biomass energy production, and a very low population density – so it should be better placed to take a leadership role in renewables development than any of these other jurisdictions. (Germany, for example, has half the land area and 80 times the population.) Instead, it is lagging behind.

In the next sections, I categorise the main available technologies useful in a shift towards sustainability, arranged according to their deployability:

[slide 14]

Mature sustainable options

There are four options which could be readily implemented immediately, to a much greater extent than at present:

- Demand side management & efficiency / conservation
- Wind power
- Some biomass
- Hydro (mostly small run of river)

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2 Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (2009:Jan), Neues Denken, Neue Energie, pp12-13. [See also pp14-15, in which the commitment of the German government to phase out nuclear power is made utterly unambiguous.] Available online in the original German at *http://www.bmu.de/energieeffizienz/downloads/doc/43103.php* and in English translation at *http://www.bmu.de/energieeffizienz/downloads/doc/44006.php* (last accessed 2009:May:22)

3 Tim Helwig-Larsen, Jamie Bull *et al* for Centre for Alternative Technology (2007), Zero Carbon Britain, CAT Publications, Machynlleth, Wales

4 Mark Barrett (2006:Apr), A Renewable Energy System for the UK, Complex Built Environment Systems Group, Bartlett School of Graduate Studies, University College London . Available online at *http://www.cbes.ucl.ac.uk/projects/EnergyReview.htm*

5 New York Times (2009:Apr:22), *Energy Regulatory Chief Says New Coal, Nuclear Plants May Be Unnecessary*: available at: http://www.nytimes.com/gwire/2009/04/22/22greenwire-no-need-to-build-new-us-coal-or-nuclear-plants-10630.html (last accessed 2009:May:22)

6 Cherise Burda, The Pembina Institute & Roger Peters (2008:Nov), Plugging Ontario into a Green Future: a Renewable is Doable Action Plan, Pembina Institute, Toronto, ON. Available online at *http://ontario.pembina.org*

7 Jeff Bell & Tim Weis (2009:Jan), Greening the Grid: powering Alberta's future with renewable energy, The Pembina Institute, Drayton Valley, AB. Available online at *http://alberta.pembina.org*

Taking these one by one,:

[slide 15]

DSM: SaskPower currently has only a handful of people working on demand side management (DSM - i.e. the utility taking its share of the responsibility for energy efficiency and energy conservation). The quoted target of 100MW capacity savings over 10 years compares poorly with other North American jurisdictions. It is generally accepted by DSM specialists that capacity savings of at least 1% per year should be possible well into the future. (The SaskPower figure represents only about 0.3% per annum.) One of the longterm success stories in DSM is California: see slide 15 in the accompanying presentation, which shows per capita electricity consumption in Washington state, California and the USA as a whole from 1960 to 2005. While the average US citizen used steadily larger amounts of electricity over this period (middle line, red), the average Californian's consumption (lowest line, blue) has remained quite consistently constant since the mid-1970s. It should be noted that during this period Californian incomes rose substantially, including the emergence of a major new industrial sector of world significance.

DSM is the least expensive option available, with costs of between 0 and 7 cents/kWh. This is an opportunity which SaskPower should not miss.

[slides 16, 17]

Wind: Saskatchewan probably has the best inland wind resource in Canada, with relatively high wind speeds and (at least as importantly) a high degree of consistency throughout the year. Slide 16[8] shows the average wind speed at 80m: green, yellow, orange, brown and red parts of the map represent an average wind speed greater than 6 m/s, a figure often used as a threshold for viability of large-scale wind. The area of the province with suitable wind speeds and a grid-accessible location is massive – certainly more than 100000 km^2. To supply 20% of SaskPower's 2030 demand projection, only 300 km^2 of land area is required (only 3 to 10 km^2 of which is needed for tower foundations, control houses, access roads etc – the rest is still usable for agriculture).

[slides 18, 19, 20]

Biomass: Saskatchewan's biomass resources consist largely of agricultural and forestry residue – straw, wood shavings, etc. To this could possibly be added some purpose-grown energy crops such as short rotation coppice willow plantations or fast-growing grasses. With existing technology, the total resource, after the need to return much of the agricultural residue to the soil has been taken into account, comes to about 800 to 1600 MW capacity, or 20 to 40% of SaskPower's projection for 2030. The SaskPower submission mentions only wood chips; gasification of biomass is another option, which could offer more flexible power and possibly higher efficiencies. Slide 18 shows a strawbale gasifier in Manitoba, used only to provide heat. The technology for electricity generation from biomass is quite well-established in Europe: slide 19 shows a combined heat and power plant in Slough, England.

The SaskPower submission lists the small typical size of biomass plants as a disadvantage. I am of the opposite opinion – a technology which can be operated on a community scale enables local employment, community economic development, and a local sense of responsibility. A move to sustainability will require SaskPower to adjust to a more decentralised, networked style of organisation – both in its grid and in its employment practices. I believe that this will empower vulnerable rural communities, in both senses of the word.

In order to be renewable and (nearly) carbon neutral, biomass needs to be grown sustainably – i.e. for every tonne harvested another tonne of the same will grow and absorb the carbon dioxide emitted in combustion. Options may well exist to move beyond carbon neutrality to a carbon negative situation: these are described below under "renewables requiring research".

Competition with food production should be avoided, by using by-products of existing agriculture and by

8 From the Canadian Wind Atlas: *http://www.windatlas.ca/en/maps.php*

growing any energy crops on land unsuitable for food crops.

[slide 21]

Hydroelectricity: A few suitable sites remain, mostly suitable for run of river sites rather than large installations with dams and reservoirs. All new hydro plants should be built and operated in partnership with local people. Hydro is likely to be able to meet about 20 to 25% of total demand in 2030

[slide 22]

Transitional technologies

In this category come relatively low-emissions fossil fuel technologies:

- Natural gas combined cycle gas turbine (CCGT) – this approach gives a higher efficiency than other types of gas-fired generation
- Combined heat and power (cogeneration) – overall emissions are reduced by recycling "waste" heat for space or water heating.
- Generation from industrial heat recovery – this should continue for as long as the relevant industries remain in Saskatchewan.
- Coal with carbon capture and storage (CCS)

[slide 23]

Of these, I have further comments only on CCS:

It should be noted that CO_2 emissions from coal are reduced by this means, but not eliminated. According to my calculations, current coal consumption results in carbon dioxide emissions of about 1220 g/kWh; with CCS this is reduced to 144 g/kWh, still significantly higher than any of the major renewables options.

The additional cost of CCS could be anything from $40 to $150 per tonne, and is most likely to be towards the upper end of that range. That works out to 5.2 to 19.5 cents/kWh – not a price tag that will be viable without government subsidy. Hence it is difficult to see CCS as a serious solution to climate change. However, it is a useful technology which merits development, if only for its potential for carbon negative generation from biomass.

[slide 24]

Renewables heading towards affordability

[slides 25 to 32]

Photovoltaics – electricity from solar cells – is the one technology in this category. While current prices are high, they are predicted to fall well below 10 cents/kWh by 2018 – see the graph in slide 25, taken from New York finance house Lazards.

Saskatchewan has the best solar resource in Canada, as is shown in the map[9] in slide 26. Slides 27 to 32 show some of the types of installation that would be suitable – in fields, on roofs and walls, and beside east-west highways (where it could also serve as a barrier to drifting snow. To supply 10% of 2030 projected demand would require about :20km^2(of which 5 – 10km^2 would be on buildings and roads)

[slide 33]

Renewables requiring research

Two biomass options have particular potential, but require serious research programmes before they can be

9 From the Atlas of Canada – Solar radiation, at *http://atlas.nrcan.gc.ca/site/english/maps/archives/5thedition/environment/climate/mcr4076*

implemented:

Biomass torrefaction is a process in which a dense solid fuel, similar to coal, is produced from less dense biomass. This has a couple of advantages. Firstly, the resultant fuel is less bulky to transport. Secondly, it should be possible to use it in place of coal in existing coal-fired power stations without a great deal of modification. If fitted with CCS apparatus, those power stations would then become carbon-negative.

Biomass resources in the province do not appear to be large enough to replace all coal by this means, but perhaps one large power station could be converted.

A volatile gas is also typically produced in the torrefaction process – this can be used as a fuel locally, for example in a CHP station.

[slides 34, 35]

Biochar is the product of a slightly different reduced-oxygen, low-temperature decomposition of biomass[10]. Under the conditions suitable for this process, both a volatile gas (suitable as a fuel) and a liquid (suitable either as a fuel or as a chemical feedstock) are produced, along with a solid residue, biochar, which is akin to charcoal. Given the right soil conditions and the right biochar texture, addition of biochar to the soil can in principle give a number of benefits:

- carbon is directly sequestered, resulting in a carbon-negative process
- carbon added to the soil increases its ability to hold nitrogen, increasing fertility
- as a result, the demand for (energy-expensive) artificial fertilisers can be reduced, and
- emissions of nitrous oxide (a potent greenhouse gas) from soil are also reduced.
- the gas produced in the process is a carbon-neutral fuel which can potentially replace fossil fuels.

Hence, if this option can be made to work successfully, it offers a win-win-win-win-win situation.

As noted above, the province's present sustainable biomass generation potential amounts to about 20% to 40% of projected 2030 demand. With successful biochar projects, using the gas as fuel and sequestering the char, perhaps only 50000km^2 worth of agricultural and forestry residue would be required for 50% of 2030 demand

I therefore consider these two technologies as top priorities for research funding.

[slide 36]

Other renewable power possibilities

Deep (enhanced) geothermal has been shown to be a serious possibility for electricity generation in Alberta. However, it appears likely that, in the continuation of the Alberta geothermal basins on our side of the border, sufficiently high temperatures for electrical generation are not achieved. This is, however, incompletely researched at present.

Concentrating solar power (CSP) stations, in which solar radiation is focussed into a small area either by large parabolic mirrors or by large numbers of appropriately-oriented linear mirrors, is typically a technology for climates closer to the equator. However, it is possible that it may become financially viable in the south of the province during the next 20 years or so. (A CSP plant has just been opened at Jülich, Germany, where the annual incident solar radiation is substantially lower than in Saskatchewan.)

Hybrid options may prove to be viable – for example, a CSP station could generate steam from water already preheated by geothermal means; or gas combustion could be used in tandem with either geothermal or CSP.

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10 See, for example: ed. Johannes Lehmann & Stephen Joseph (2009), Biochar for Environmental Management – science and technology, Earthscan, London

[slide 37, 38, 39]

Grid Integration

The variable nature of certain renewables (especially wind and solar) is clearly viewed in the SaskPower presentation as a barrier to their development. If SaskPower are to continue to run the grid in the same way it always has, this is no doubt true. However, there is more than one way to run a grid, and what appears a barrier should, I believe, be seen as an engineering challenge[11]. Instead of giving priority to "baseload" generation, for example, jurisdictions with a high level of wind penetration will give priority to wind power. Indeed, as FERC chair Jon Wellinghoff said in the same interview as was quoted above,:

"I think baseload capacity is going to become an anachronism".

This is already becoming the case in European countries with high wind power penetration. For details on the integration of wind in Denmark (where the western grid is supplied about 25% from wind, and the eastern grid about 12%), see www.energinet.dk

[slides 40 to 47]

There are several techniques suitable for "smoothing" variable power, which should be considered together as a package:

- A wide geographical distribution – when the wind is weak in Rosetown, it may be stronger in Porcupine Plain, and vice versa.
- Pair wind with hydro – when the wind is strong, the water stays in the reservoir; when the wind is weak, there is then more capacity for power production at the hydro plant.
- Establish a mutual trading arrangement (and strengthened interties) with Manitoba Hydro – which generates about 97% of its power from hydro. Denmark has a similar arrangement with Norway and Sweden.
- Optimise the wind/pv mix – solar plus wind, if properly proportioned, is a less variable combined source than either on its own
- Use DSM for load management – with a smart grid arrangement, the timing of some electrical demands can be optimised to improve the matching of demand and supply. (For example a pump which needs to run at a non-specific time, or refrigeration which can be delayed for a couple of hours)
- Storage. This should probably not be necessary until wind penetration reaches at least 20% of power output. A number of options exist, of which the most promising are pumped storage (in Saskatchewan, pumping could be between a surface reservoir and an underground reservoir in an abandoned mine), vanadium flow cells and compressed air. Additionally, significant market penetration of plug-in hybrid and fully electric cars will offer the prospect of significant distributed storage of power in car batteries. Slide 46 shows the operation of pumped storage diagrammatically, and slide 47 the Adam Beck hydro plant at Niagara, one of whose units is used for pumped storage.

The Danish western grid currently uses only the first 3 of these options (though the 5th is being actively researched and tested), and successfully integrates some 3 times as much wind power as SaskPower are currently claiming is their upper limit.

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11 For detailed discussion of the challenge, see, for example: ed. Godfrey Boyle (2007), Renewable Electricity and the Grid – the challenge of variability, Earthscan, London

[slides 48, 49]

Greenhouse gas emissions

Renewables result in very substantial savings in greenhouse gas emissions compared to conventional generation options. The following are estimates taken from recent research:

	GHG emissions (g/ kWh)
Coal[12]:	1220
Coal with CCS[13]:	144
Nuclear (today)[14]:	66
Nuclear (0.013% ore)[15]:	255
Gas[16]:	250 to 600
Wind[17]:	6 to 11
Hydro (run of river)[18]:	3 to 4
Hydro (reservoir)[19]:	10 to 33
Biomass[20]:	20 to 59
PV (crystalline)[21]:	30 to 60
PV (thin film)[22]:	15 to 40

[slide 50]

Other benefits

Renewables – and even more so efficiency/conservation – have been consistently found to generate more jobs per dollar investment, and more jobs per kWh, than either fossil fuel or nuclear. With the renewables mix appropriate for Saskatchewan, those jobs would be local, strengthening communities and sparing families the difficulties associated with the long absence of the breadwinner.

Small rural renewables provide an excellent opportunity for community enterprise: Denmark's second largest export industry (after butter) came into being as a result of farmers' cooperatives purchasing wind turbines.

No energy source is entirely free of environmental problems, but those associated with the renewables are minor

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12 Calculated from publicly available data for Saskatchewan coal

13 Calculated from publicly available data for Saskatchewan coal, and SaskPower assumptions re carbon capture efficiency and CCS power requirements

14 Average of a number of studies, from Benjamin K Sovacool (2008:Jun), Valuing the greenhouse gas emissions from nuclear power – a critical survey, Energy Policy 36 (2008): 2940-2953

15 Adjustment of Sovacool's results in proportion with the results presented by Jan Willem Storm van Leeuwen at www.stormsmith.nl

16 The low figure is for CHP from CCGT

17 From LCA studies carried out by NEEDS, CASES, Ecoinvent and Vestas – see: *www.wind-energy-the-facts.org/en/environment/chapter-1-environmental-benefits/lca-in-wind-energy.html*

18 Hydro Quebec figures

19 Hydro Quebec figures

20 Elsayed, Matthews & Mortimer (2003)

21 Based on V M Fthenakis, H C Kim & E S Alsema (2008), Emissions from Photovoltaic Life Cycles, Environ. Sci. Technol, 2008, 42, 2168-2174

22 Based on Fthenakis, Kim & Alsema, op cit.

compared to the cocktail of toxic emissions from coal, or the unsolved long-term storage problem of nuclear spent fuel.

Policy recommendations

- Energy efficiency should be encouraged (i) by writing a requirement for it into the documents defining the purpose of SaskPower, (ii) by learning from the experience of states such as California, Vermont, New York and Oregon, (iii) by recruiting to SaskPower sufficient staff to be able to emulate the experience of those states, and (iv) by eliminating all perverse incentives, by which larger users are charged a discount rate for electricity
- CHP and/or power from heat recovery should be encouraged through a system of incentives for good behaviour and taxes for energy waste.
- Saskatchewan should follow the recent good example of Ontario, and the long-established practice of the European leaders in the field, by introducing feed-in tariffs. This would give individuals, families and communities the right to change their role from consumer to net producer, and give them an assured price. Premium rates and administrative assistance should be given to indigenous groups and (to a lesser extent) to local community groups and cooperatives. Penetration of the market by outside groups should be limited by law, and clear partnership agreements should be established between SaskPower and local producers.
- Nuclear power should be rejected as a power generation option for Saskatchewan. AECL's recent Ontario quote for $12000/kW capacity is the equivalent of a cost to the utility of about 20 cents/kWh (for full nuclear chain costs, but not including grid strengthening, operator profits or insurance). Wind, biomass and hydro are all cheaper, and photovoltaics are projected to be cheaper within a few years. And none of these options carries with it the environmental and public health risks associated with the nuclear industry.
- The Saskatchewan government should move rapidly to put in place retraining facilities for coal miners and workers at coal-fired power stations, and facilitate good terms for transfer into the emerging renewables industry. It is possible that, by using torrefaction, one of the three large coal-fired plants could be kept open, but the others would need to close (or convert to wood chips). A clear plan for the transition from coal should be developed.
- SaskPower should be required to redesign their grid operation parameters such as to be able to sustain a wind penetration of at least 20%.
- All new SaskPower meters and switches should be chosen for smart grid compatibility, and a plan developed for establishment of a smart grid in the province.
- Northern communities and indigenous groups should have access to funds earmarked for local energy plan development. For remote communities, local energy plans not dependent on SaskPower should be an option, provided that they use local resources only and are maintained under local democratic control.
- Research in key areas – including biochar, torrefaction, biomass CHP, anaerobic digestion in cold climates, photovoltaics, storage technologies and smart grid technology – should be established and publicly funded at the province's universities. SIAST should be equipped to teach skills in installation and use of renewables.
- SaskPower should be asked to revise their figures for the cost of nuclear power and coal with CCS, both of which are either serious underestimates or else assume hidden government subsidy.