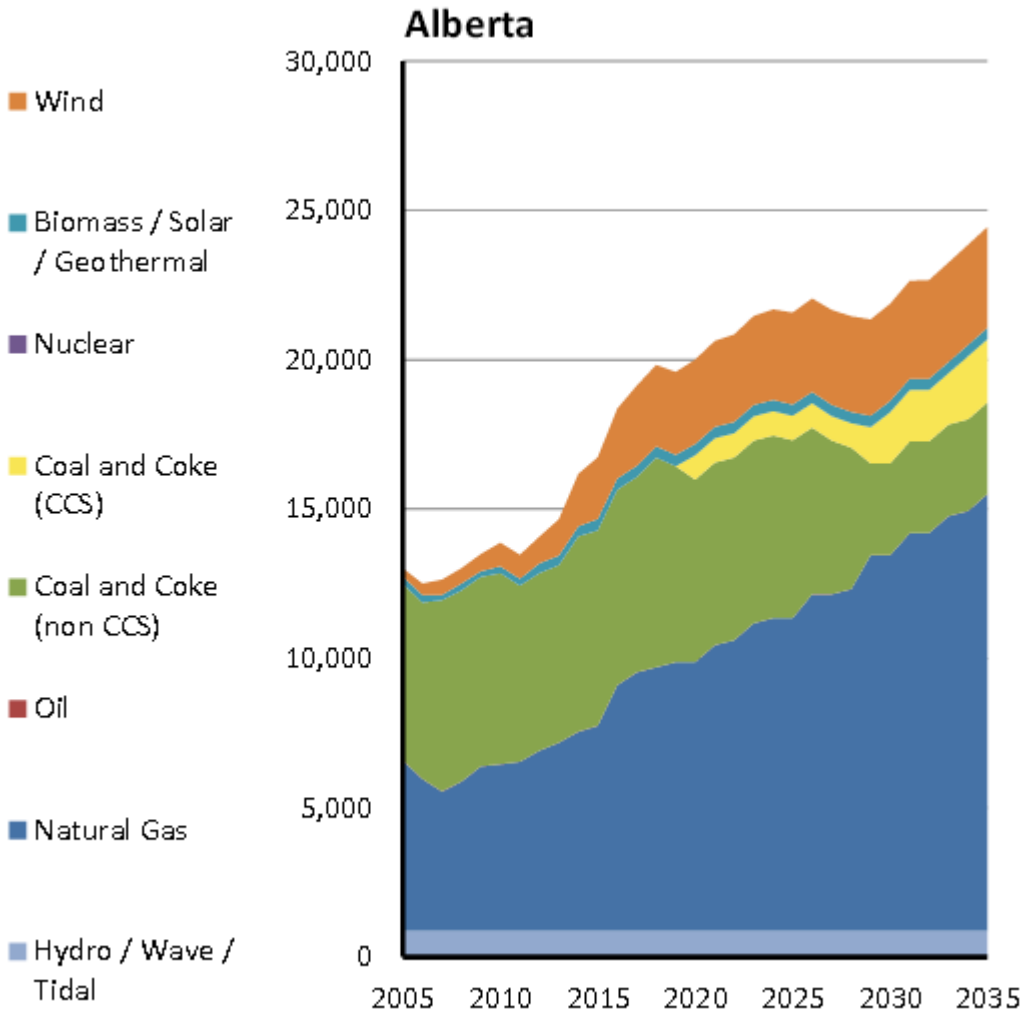
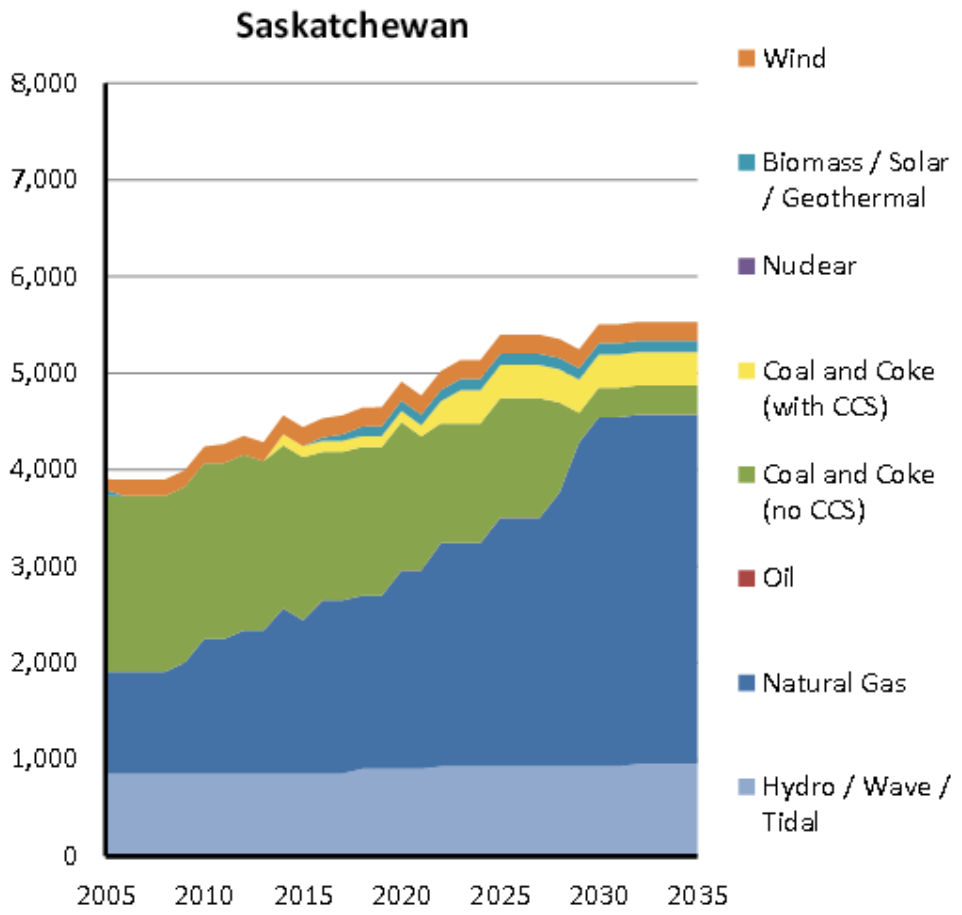
Prairie power

The densely populated parts of Canada all have similar building types and nearly the same climate so they all have essentially the same energy use patterns. However, only two of the provinces (Saskatchewan and Alberta) also have similar energy supply sources so their residential energy needs can be dealt with together.

In May (2013) the Alberta government published its latest review of GHG emissions in which it reported that in 2011 Aberta emitted 48.5% of all of Canada's emissions from large stationary emitters, a definition that excludes buildings. The oils sands operations accounted for 39.8% of the province's emissions in this category but the emissions from power generators were not far behind at 35.4%. The power was primarily generated using coal as the energy source so in addition to the GHG emissions there were also high levels of the other pollutants associated with burning coal.

Not surprisingly, the general assumption is that Alberta (and Saskatchewan as well) will switch to the use of natural gas for power generation. The following are the NEB's predictions for future natural gas consumption in Alberta and Saskatchewan:

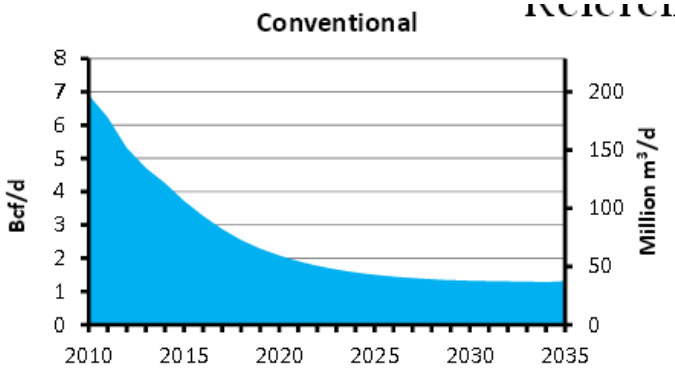




Note that Alberta has no immediate plans to make the switch and that both provinces will make some use of carbon capture and storage, beginning in 2018 in Alberta, and that Alberta plans to continue to use some coal throughout the period (which covers the years 2005 to 2035). Alberta also plans to make some use of wind power but it will only account for a small portion of the total. The NEB expectation is that natural gas will account for the overwhelming part of the power generation and for the growth of consumption for heating applications.

The question is: Where will the gas come from?

The NEB data shows that the natural gas produced by conventional means will continue to drop quickly:



The NEB reports (which virtually ignore GHG) assume that most of the future gas will come from shale gas and tight gas sources that are mostly located in BC but that have some potential in Alberta and Saskatchewan as well. However it is almost certain that the fugitive emissions from fracking will in time rule out that option so the plans being made by both provinces (and by the federal government) are bubbles that will soon burst. A basic argument behind those plans is that it would not be possible for those provinces to switch to renewable energy sources like wind and solar because such sources are intermittent. There will be times when there will be no wind and no sunshine but since coal is not an acceptable option and there is very little hydro the argument is that natural gas is the only remaining option (they simply ignore the potential to use nuclear power).

Exergy storage and Atmospheric Energy systems will prick those bubbles because they store the energy that is needed for most of the heating and power demands, deflating the argument that renewable sources are intermittent.

However, exergy storage systems cannot deal with the case where there is no source of electricity at all (as in the PEI case) unless there is some way of maintaining the electricity supply when all of the intermittent sources are down. PEI can cope by relying on a link to a larger neighbouring province (NB) to absorb the surplus and deficit supply periods, and that link is already in place. In principle AB and SK could likewise use storage systems to reduce their net power needs to zero and use links to BC and MB for balancing but those links are not currently in place and are not planned for. SK produces some hydro power but AB produces very little hydro power. That makes it necessary to examine the actual energy demands and consider the possible supply choices to see if there is a workable alternative.

As in the previous reviews, the NRCan OEE data for residential energy in 2010 will be used as a guide:

Energy source	**Alberta**	**Saskatchewan**
Electricity	37.6 PJ	11.8 PJ
Natural gas	160.0	36.0
Heating oil	0.3	0.6
Other (coal, propane)	1.7	1.0
Wood	0.5	1.1
TOTAL	**200.1 PJ**	**50.5 PJ**

Application	**Alberta**	**Saskatchewan**
Space heating	127.7 PJ	31.0 PJ
Water heating	42.1	10.6
Appliances	22.6	6.5
Lighting	7.5	2.0
Space cooling	0.2	0.3
TOTAL	**200.1 PJ**	**50.4 PJ**

At the present time Alberta has 33 power generating stations (3,591 MW) that use natural gas but together they are produce less power than the 8 large coal-fired stations (that generate 5,695 MW). Saskatchewan has 10 natural gas-fired stations (1,639 MW) and 3 coal-fired stations (1,682 MW). In addition, Alberta is generating 918 MW of hydro power and Saskatchewan is generating 853 MW of hydro power (source: Wikipedia lists of power stations).

Table 2 shows that 169.8 PJ of heat is currently being used for heating applications and 30.3 PJ of electricity is being used for appliances and other non-thermal applications. The 169.8 PJ of heat could be supplied by exergy storage systems but such systems need electricity to drive their heat pumps. In this case the COP of the heat pumps should exceed 4 (to be explained later) so the total electricity consumption would rise to 168.9/4 + 30.3 = 72.5 PJ per year. The total energy demand is still 200.1 PJ but now no combustible sources are being used for heating and 127.6 PJ of Alberta's energy needs are being supplied by the heat extracted from the air and the solar energy collected by the exergy systems.

The exergy heat pumps operate at night and the timing is completely controlled by the grid operator so they will be operated only when the power demand of the other uses is minimal (primarily appliances). To a first approximation the power consumption would be 42.2 PJ at night and 30.3 PJ during the day. That means that the electricity generation capacity (MW) would need to be increased by at least 12% and the total electricity consumption would increase by 34.9 PJ per year.

You can use either solar power or wind power to supply the needed generation capacity (MW) thanks to the fact that the 42.2 MW of power used for exergy storage can be supplied at any time, day or night, and can take advantage of both bright, sunny days and periods of strong winds. Such systems are no longer constrained to a requirement that their generation must be limited by the current grid demand. Alberta's future plans for wind generation are already sufficient to meet the power demand and the residual deficit in total electricity supply could be made up by adding solar panels to the exergy storage systems so that the panels become dual-function units.

The NEB projection shows Alberta's energy demand doubling by 2035. The air is for all practical purposes an unlimited source of energy so that component can handle the growth in thermal demands. However the above calculations assume that the existing power generation facilities remain in place (the additions were needed to drive the heat pumps, not to replace the coal-source power). The exergy source systems will get rid of the GHG that is currently being generated by heating systems but it does not deal with the GHG from the coal-fired and gas-fired power generators, and it does not deal with the need to double the generation capacity by 2035.

About 7.3 PJ of the electricity production is currently being used for thermal applications so for the other applications there is a need to generate 30.3 PJ per year at the present time, growing to about 60 PJ per year by 2035, and to phase out the coal-fired generation altogether. If Canada stopped exporting natural gas to the US altogether then it might be able to conserve enough conventional natural gas to meet the power generation needs (bearing in mind that the larger rates of consumption are for space heating and have been replaced by heat drawn from the air). The amount of natural gas that would be needed would be only a small fraction of what the NEB proposed.

Eventually the supply of conventional natural gas will peter out, at which time AB and SK will have to turn to wind, solar, nuclear or some other more sustainable source of electricity. Using the air as the source of thermal energy is a giant step in the right direction but it does not provide a universal answer.

Data for Saskatchewan to be added, together with an explanation showing why exergy storage is less expensive than the use of natural gas.