4. Looking beyond the energy system

Some Canadian GHG emissions are not directly related to energy use, but stem from industrial processes and products (7.5%), agriculture (8.4%) and waste (2.6%). These emissions, which are entangled with a variety of existing systems of provisioning, may be particularly challenging to address. Industrial processes include the production of iron, steel, and cement (the critical structural materials of industrial society) and the manufacture of chemicals. Industrial products include fluorinated gases used in refrigeration, air conditioning and heat pumps, as well as other industrial and commercial applications. Agricultural emissions are generated by livestock operations (from enteric emissions and manure) and cropping practices (fertilizers, agricultural soils). Landfill and waste-water treatment facilities also generate substantial GHG emissions. Moving towards net zero, system transformations must successfully address both energy and non-energy emissions, and these will be discussed together in subsequent sections of this report.[29,30,33]

Although the journey to net zero is primarily about building systems that avoid GHG emissions, it will also involve some application of 'negative emission' approaches that remove carbon dioxide from the atmosphere. This will be required to offset residual emissions which prove technically challenging or too expensive to eliminate. For example, if CCS is applied to fossil energy production and use, or to control industrial process emissions, residual emissions of perhaps 10% will have to be offset by removals. And while accidental methane releases associated with fossil energy production and usage can in principle be reduced to low levels, negative emissions approaches may be required to deal with these.

Moreover, even if all fossil energy usage stops, or novel exploitation techniques completely avoid GHG releases, negative emissions approaches may ultimately be required to draw down atmospheric GHG concentrations. Most integrated assessment models indicate these approaches will be needed in the second half of this century if the impacts of climate warming are to be kept within a manageable range.[1,2] Although some argue that these models have not accounted for more dramatic demand-led systems changes that might avoid the need for negative emissions, the longer climate action is delayed the more potential significance they acquire.[34]

A wide array of negative emission approaches has been suggested, including:

- large scale reforestation and afforestation. As trees grow, they absorb carbon dioxide and convert it into standing biomass. If the forest remains undisturbed, the carbon is locked away from the atmosphere.[35]
- increased retention of carbon in soils through changes to agricultural practices and/or the wide scale incorporation of biochar.[36,37]
- bioenergy carbon capture and storage (BECCS), where biomass energy facilities apply CCS to trap the carbon dioxide drawn down by plant growth underground.[38]
- direct air capture (DAC), where CO_2 is extracted from ambient air and sequestered underground or used as an input for industrial processes.[39]

Each approach has different potential as well as difficulties or drawbacks. For afforestation and reforestation, concerns are with the vulnerability of sequestration to fires, pest and disease attack, or human activities as well as the availability of land. The ultimate potential for organic carbon retention in soils remains uncertain, while there is still little systematic research on biochar. BECCS is currently expensive; energy is required to collect dispersed feedstocks, and there are doubts about the availability of bio-resource feedstocks without negative land use impacts. Air capture is currently very expensive and energy intensive but could ultimately be linked to synthetic hydrocarbon production. Other approaches are possible. But there are persistent doubts about the funding of removal activities, the scale at which they could be undertaken, and possible negative environmental impacts of many of them. Several recent reports provide an overview of negative emission approaches and the frameworks required for their governance.[40, 174]