



## 10. PATHWAY REPORTS

One-page reports for each Pathway are included in Appendix 6; the grid and profile charts present the opinions of the Proponents and the

Evaluators. The following are summaries of the messages learned for each pathway, as understood by the Task Force.

No.	Pathway	Message
1	Coal Gasification with CO <sub>2</sub> Capture	Gasification technology is proven but not clearly economic in Canada at present. Demonstration scale projects including CO <sub>2</sub> capture using Canadian low rank coals and coke and next generation technology improvements are needed. While gasification will largely be regional using coal, a successful demonstration project could lead to a platform for gasification of biomass country-wide.
2	Clean Coal Combustion (including CO <sub>2</sub> capture)	This is an alternative route to gasification to utilize our coal reserves to produce electricity. This combustion process avoids the operational complexities of gasification but also does not produce the ancillary feedstocks. The key area on which work is needed relative to our most recent cleaner coal plants (Genesee) is CO <sub>2</sub> capture.
3	Energy Products from Agricultural & Forestry Feedstocks	There are a large number of directions that could be taken in producing energy products from both agricultural and forestry feedstocks. In many cases regional factors would be key drivers. A national coordinated network is needed to incent and share information on a series of regional demonstration projects that could result in significant upgrades to current technologies.
4	Power from Agricultural Feedstocks (Straw)	This pathway would be a candidate for one of the nodes of the national network identified for Pathway 3.
5	Power and Heat from Municipal Solid Waste	Current technology in use in Europe and the US avoids the emissions problems of the incinerators of the past. This pathway is inherently CO <sub>2</sub> neutral (and would be CO <sub>2</sub> positive if long distance garbage haulage was displaced) and could be a feedstock for gasification technology. Regional demonstration projects as part of the national network of Pathway 3 would be appropriate as a means of encouraging use of this pathway.
6	Wind Farms for Grid Supply	The technology for producing electricity by wind turbines has increased rapidly in recent years to the point that wind power is a growing component of most power systems that have good wind profiles. However, this technology has a large footprint relative to the power output and studies and technology improvements are needed to address issues of integration with power grids and more effective storage of the energy generated to mitigate the intermittency of the resource.
9	Solar Energy for Electricity	It is likely that Canada will not be a leader in the massive technology development efforts that will be needed to achieve the potential of this pathway. However, work on issues such as integration with the grid and storage referred to above for wind energy could contribute to the effectiveness of this pathway.

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11	Low Impact Surface Mineable Oil Sands	The current approach to extracting and processing our surface mineable oil sands resource is not environmentally acceptable. Work is needed to identify step changes to the 40-year old technology that is now being used.
12a	Solvent Vapor Extraction Processed Heavy Oil	The technology for this is immature and financial support is needed for field testing processes that look promising based on bench scale testing.
13	Alternative Hydrogen Supply for Oil Sands Development	Continued reliance on natural gas to produce hydrogen for use in oil sands upgrading is a questionable use of our natural gas resource and environmentally unacceptable. Research is needed on alternative technologies that could combine Canada's existing strengths in nuclear power and hydrogen production.
14	Value-added Products from Oil Sands Development	Research is needed on technologies to use in local processing of the raw materials extracted from our oil sands such as to make the best use of the outputs based on their chemical structures. New science is needed in this area.
15	Nuclear Fission Energy for Oil Sands Development	Our world leadership position in the SAGD process combined with our proven nuclear power plant technology could be leveraged to greatly reduce environmental impacts of the current process. Research is needed on effective integration of centralized steam production with dispersed well injection (to overcome long distance steam transportation challenges), electricity production and water/air cooling requirements
16	Alternative Energy System for Road Vehicles	As automobile designs are controlled outside Canada, we are not likely to play a lead role in developing this technology. However, research on the cold climate aspects of the technologies and on battery technology would be beneficial and could secure an advantage for the Canadian auto parts industry. Widespread adoption would have impacts on power system operations by increasing overnight load levels and this warrants assessment.
17	Upgrades to Electrical Infrastructure (was not undertaken as a separate pathway but related issues were raised in other pathways)	There are three challenges related to a national electrical grid system <ol style="list-style-type: none"> <li>1. A national grid system linking most or all of the provinces with high voltage transmission lines capable of transmitting relatively significant amounts of power</li> <li>2. Technology to allow more effective connection of larger amounts of intermittent renewable-based generation to the local grid without compromising system operations</li> <li>3. Technology to allow more cost effective storage of the energy from electricity produced from intermittent sources and off-peak base loads.</li> </ol>
18	Hydrogen Production, Transportation and Use	Production of hydrogen for industrial use is important on a regional basis. Improvements in the technology for hydrogen production are needed (see Pathway 13).
19a	Geothermal Borehole Thermal Energy Storage (BTES) System	The basic technology for this is in place and use of this technology can reduce strain on electricity grids and bring significant reductions in GHG depending on the fuel being displaced. Work to reduce materials and installation costs would be beneficial.

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19b	Mid-depth and Deep Geothermal Energy	The technology for this is not highly developed and we do not have a national survey of the resource base. Trials of heat exchanger technology could be carried out using existing oil wells in Western Canada.
20	Natural Gas Hydrates	While it is believed we have a massive resource, little detailed information is available and there is currently no technology for the large scale, practical recovery of this resource. Canada should expand its research efforts in this area, starting with mapping and delineating the resource base and assessing the potential and risks involved in future exploitation. Due to the widespread global occurrence of gas hydrates, there is a potential for technology export.
21	Development of Coal Bed Methane	These resources are currently being recovered in a number of wells in Alberta. Incremental improvements in the technology will take place driven by the market. R&D on mitigating the environmental aspects, particularly water use, is needed.
23	Tidal and Wave Energy for Electrical Power	While the idea is not new, modern technology for this is in its early stages of development. Our candidate sites are typically in areas where other energy sources are limited and thus this technology could make a significant contribution. Demonstration projects would be needed to confirm the potential.
24	Carbon Dioxide Capture, Transportation, Storage and Use	Effective and economical CO <sub>2</sub> capture, collection and storage will be an enabler for many other pathways. While there is a major pilot in Weyburn Saskatchewan in using CO <sub>2</sub> for enhanced recovery, major and immediate efforts are needed at the national level to develop the related technologies for both new projects and to retrofit some existing large emitters. Such efforts are recommended as a national priority.
25	Advanced Fission Reactors for Electrical Power	Nuclear power is a very important component of a reduced carbon world. Continuing support for development of advanced generation reactors is desirable and would build on our leadership in providing proven nuclear power technology. In addition, work on developing technology for recycling nuclear waste could result in a world leadership position.
26	Magnetic Confinement Fusion for Electrical Power	Canada should maintain a watching brief on ongoing international efforts and contribute in areas where we have appropriate expertise, such as in the production and handling of tritium. This will give us a "seat at the table".
27	Inertial Fusion Energy for Electricity	In view of recent more promising outlooks for inertial confinement fusion, it is suggested that Canada's academic community provide support to ongoing international efforts in this field.
28	Recovery of Bitumen from Carbonate Deposits	Previous recovery efforts related to this large resource base have not been encouraging. Knowledge about the geology and effective and economic extraction methods is limited. More work is needed on reservoir characterization and improved recovery approaches before this resource will have any significant impact.
29	Increased Conventional Oil Recovery	Increased recovery is an important near-term objective to ensure effective resource utilization. Development of the technology is likely to be incremental and largely market driven. This technology is a primary application for CO <sub>2</sub> captured in energy production facilities (such as coal gasification plants).
29b	Enhanced Oil Recovery by Air Injection Processes	This technology is likely to be applicable in niche applications and improvements will likely be incremental and largely market driven.
30	Increased Natural Gas Recovery	Technology improvements will be incremental and largely market driven.