



ACKNOWLEDGEMENTS

Canadian Academy of Engineering

Energy Pathways Task Force Phase 1 – Final Report

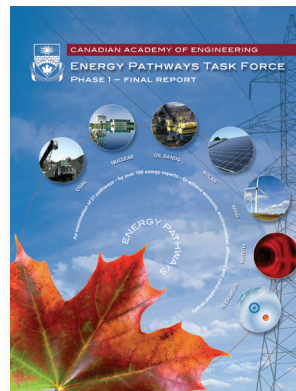
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The eight sponsors of this initiative provided significant financial and in-kind support without which this project would never have been attempted. This report, however, does not represent the views of organizations, rather it reflects the opinions of knowledgeable individuals in both the public and private sector concerning the enormous energy opportunities available to Canada.

There were more than a hundred people involved in the project, including members of the Academy Task Force



who led the activity, the Proponents of 27 energy pathways, and the Evaluators who matched their judgements against those of the Proponents. The Proponents deserve an extra measure of praise; they agreed at the request of the Academy to prepare pathway descriptions and to carry out their own assessment, an act of some courage.

The authors of this report thank all those involved in the project, with special mention to:

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Oil sands photo on cover and page 9 courtesy of Suncor Energy Inc.



The Canadian Academy of Engineering (CAE) comprises many of the country's most accomplished engineers, who have expressed their dedication to the application of science and engineering principles in the interests of the country and its enterprises. The Academy is an independent, self-governing and non-profit organization established in 1987 to serve the nation in matters of engineering concern.

It is an active member of the *International Council of Academies of Engineering and Technological Sciences (CAETS)*, which involves 24 other leading countries.

Members of the Academy are nominated and elected by their peers to honorary Fellowships in recognition of their outstanding contributions, their distinguished achievements and leadership in the Profession of Engineering in Canada and in the wider community of the country. There are at present some 300 active members, plus 90 emeritus members. Members work closely with the other national engineering associations in Canada, and with the other Canadian academies that comprise the *Council of Canadian Academies (CCA)*. Fellows of the Academy are committed to ensuring that Canada's engineering expertise is applied to the benefit of all Canadians.

So what led the Academy to undertake an examination of the various pathways connecting energy sources to final end users? Put simply, it has risen out of a growing concern related to the collision between energy and the environment, the intersection of which represents the dominant issue facing the planet over the present century.

Where is Canada positioned with respect to this issue? Here is our assessment:

1. Canada does not have a "national narrative" that describes a common vision for the country in which all regions participate. Where are the successors to the visionary leaders who built the national railways, the St Lawrence Seaway, energy pipelines and our universal health care system?
2. Several of our major, long-standing sectors, such as the automotive and forestry industries, face serious challenges, in spite of intensive efforts to resolve the problems.
3. Energy is one of the cornerstones of civilization and is central to Canada's economic and social well-being, but we lack a compelling national energy vision. With huge unequaled energy resources, will Canada be able to produce upgraded energy products at reasonable prices with acceptable environmental impacts? New technology will be

TABLE OF CONTENTS

1. Executive Summary	5
2. Introduction	7
3. Energy Pathways	9
4. Setting the Stage	12
5. The Evaluation Matrix	13
6. Language Ladders	14
7. Proponent Pathway Documents and Self-Assessments	15
8. Explanation of the Output Reports	16
9. Database Results	17
10. Pathway Reports	18
APPENDIX 1	
Sponsors	21
APPENDIX 2	
CAE Energy Technology Task Force	22
APPENDIX 3	
Pathways and Proponents	23
APPENDIX 4	
Evaluators	25
APPENDIX 5	
Language Ladders	27
APPENDIX 6	
ProGrid Output Reports	31
APPENDIX 7	
Pathway Summaries	58

needed, but success will also require effective public policy and new concepts of risk sharing.

Transformational changes will not be made through the efforts of individual companies, nor governments acting alone.

If we are able to bring about such transformational changes, it has been suggested that Canada would become a “sustainable energy superpower”. The Canadian Academy of Engineering represents engineers who build things. Engineers build to a design specification, for the benefit of all Canadians. What are the design specifications for a Canada that is a “sustainable energy superpower”? Energy experts, politicians and citizens will have varying views on an appropriate definition.

Regardless of the precise definition, as engineers, it is our role to ensure that we have the technological capacity to make the following contributions to a new and expanded domestic and international energy role for Canada:

- To enable a planned and consistent shift to economic renewable energy resources.
- To make significant reductions in the environmental impacts from energy recovery, processing and use.
- To meet the current and future energy demands of all Canadians on a sustainable basis.
- To export valued-added energy products and thus be able to maintain balanced trade relations with our major trading partners.

It should be stressed that this report is not a “policy document” but rather an examination of some 27 energy pathways tracing the principal routes from our rich endowment of energy sources to their ultimate end use.

It is particularly important to note here that the energy pathways assessed are by no means a complete listing

of all potential pathways. Rather, each pathway studied was selected by an individual experienced and knowledgeable engineer who considered it sufficiently important to make the effort to act as a proponent and prepare a submission. While perhaps not as exhaustive in scope as a commissioned study might have been, the collection of resulting assessments is an important achievement of Canadian engineering in identifying what needs to be done to move towards a desirable future.

This Energy Pathways Report should be positioned with two other related studies: the CCA study on *The State of Science & Technology in Canada* and the Report of the National Advisory Panel on Sustainable Energy Science and Technology, *Powerful Connections: Priorities and Directions in Energy Science and Technology in Canada*. All three reports are in large measure complementary. The CCA study identifies Canadian scientific strength in certain areas, e.g. oil sands, but then shows the perceived shortcomings in the capacity to build sustainable dominance in the area. The ‘pathways’ are quite specific about what needs to be done to get there. The National Advisory Panel stresses the need for a systems approach to dealing with the energy issues they identify, and the ‘pathways’ clearly call for a systems approach in the challenges they identify. This is a most fortunate conjunction of circumstances, as the three reports taken together constitute a much stronger statement about what needs to be done than any one of them taken alone.

On behalf of the Canadian Academy of Engineering I am confident that this report will make a meaningful contribution to the continuing dialogue on the directions needed if Canada is to become a sustainable and environmentally sound energy superpower.

Sincerely,



Dr. John D. McLaughlin, FCAE
President, Canadian Academy of Engineering
May 2007

allocate resources, and track performance against the objectives. The mandate of the Board should also include Life Cycle Assessments to assess both the net energy gain and the net environmental impacts for each energy initiative. It is worth noting the success that the Alberta Government had, commencing in 1975, in the establishment of the Alberta Oil Sands Technology and Research Authority (AOSTRA). This body carried out major innovative programs over fifteen years with combined private/public sector funding in the order of one billion dollars. A similar commitment in each of the above three national projects would put Canada on the path to a sustainable energy superpower and would attract the skilled people needed to achieve this vision.

The Canadian Academy of Engineering would be pleased to cooperate with other stakeholders to help define the scope of these National Technology Projects as Phase 2 of this energy pathways project. With recognition that future phases will be much more demanding, both in terms of cost and management – at least an order of magnitude larger.

RECOMMENDATION 2

Network for Bioconversion Demonstration Processes

There are many opportunities across Canada for distributed and environmentally friendly processes for generating energy products from agricultural, forestry, meat and fish waste processing and municipal solid waste feedstocks, which in total would make a significant contribution to Canada's energy requirements. Existing organizations such as BIOCAP Canada and CBIN (Canadian Biomass Innovation Network R&D Program) will be able to assist in the identification of priority feedstocks and processes. A national network to conduct regional demonstration projects should be formed and funded.

RECOMMENDATION 3

Pursuing Energy Opportunities and Challenges

There are challenges in the Canadian energy sector which need new or advanced technology. In some areas, Canada has significant opportunities related to unique energy resources and should lead in carrying out basic and applied research leading to future commercial applications and technology export opportunities. In other areas, there will be opportunities to adapt technologies developed elsewhere for application in Canada. Organizations active in these areas should prioritize and coordinate their activities with the objective of significantly accelerating the pace of progress.

Examples of these challenges are:

- Water supply, treatment and management
- Wind and solar
- Natural gas hydrates
- Lower impact surface mineable oil sands
- Higher valued products from heavy oil and bitumen
- Alternative hydrogen supplies
- Potential for nuclear power for insitu oil sand production
- Advanced nuclear fission reactors, including nuclear waste management
- Bituminous carbonates
- Geothermal
- Tidal and wave

RECOMMENDATION 4

Fusion Energy

Canada should maintain sufficient expertise in fusion research to monitor and periodically assess the progress made by the international community.

- The international effort in magnetic confinement fusion is very large and commercialization is many decades in the future. 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.
- Inertial confinement fusion, once considered to be even further away in application, has made recent advances and it is recommended that a university-based effort in Canada be defined and supported as a contribution to the international effort.