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# ENGINEERING HISTORY PAPER #105

# "Some Thoughts on S&T, R&D Policies"

**by Andrew H. Wilson**

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EIC HISTORY AND ARCHIVES

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THE CEDARGROVE SERIES OF

DISCOURSES, MEMOIRS AND ESSAYS

#59/2022

# SOME THOUGHTS ON S&T, R&D POLICIES

# … AND ENGINEERING

by Andrew H. Wilson

April 2022

**Abstract**

The serious Canadian debates on federal Science & Technology and Research & Development Policies began in the 1960s, along with the Government's potential roles in the encouragement of them, and especially in regard to manufacturing. The debate on *engineering's* role in association with them has not yet begun. This paper will look briefly at the policies' historical development in a federal context.

This paper concludes that, as an essential component in the processes involving S&T and R&D, engineering has been ignored, and that this has been detrimental to the process as a whole. Some suggestions for change have been made.

**About this Series**

Principally, the Cedargrove Series is intended to preserve some of the research, writings and oral presentations that the author has completed over the past half-century or so, but has not yet published.

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**About the Author**

He is a graduate in mechanical engineering (1949) and the liberal arts (1954) and has held engineering and administrative positions in industry in the United Kingdom and engineering, administrative, research and management positions in the Public Service of Canada, from which he retired over 30 years ago. He became actively interested in the history of engineering on his appointment (1975) to chair the first History Committee of the Canadian Society for Mechanical Engineering (CSME). He was later president of CSME and of the Engineering Institute of Canada (EIC), and chairman of CCPE's Canadian Engineering Manpower Council (CEMC) and the Canadian Association for the Club of Rome (CACOR).

The research for this paper was intended originally to be part of a large Sesquicentennial one commemorating *150 Years of Engineering in Canada.* But as the material for it accumulated, there had to be some rearrangement of the subject matter into smaller parts, one of which (this one) is about policies for Science & Technology and Research & Development. All the other parts of the original paper have been included somewhere in the Cedargrove Series.

**To set the scene…**

Over the past 50-odd years, I have collected thousands of newspaper clippings, hundreds of papers and reports, and dozens of books on statistics and policies for federal science and technology and research and their corresponding expenditures. As well, I spent 14 years as a research staff member of federal advisory councils that studied these subjects, and have already written about them. It was perhaps inevitable that I should revisit some of these sources as part of my recent Sesquicentennial project, which began several years ago and is only now being wrapped up…and especially since engineering has not been discussed in the published material. Engineering has, it seems, been assumed as a component part of science or of technology, both of which, in my view, are bodies of knowledge, representing 'know-why' and 'know-how.' Engineering, on the other hand, is an activity, like research..

Engineering has been defined in a variety of ways over the years. Recently, for example, it has been associated by some with *applied* science or with technology…which may or may not be so. I prefer the definition of it as "an informed a*ctivity,* performed by purpose-trained practitioners, in regard to the design, production and maintenance of machinery, constructions, processes and devices, augmented constantly by experience and research, and by information that requires some understanding of economics, business and markets, the law, the social sciences and politics, and an appreciation of the future as well as the past."

Almost all of what follows pertains to the policies and programs of the Government of Canada, and some of its departments and agencies and omits the established provincial programs. Their inclusion, and the variety of the programs, to the federal level of detail, would have 'overloaded' this paper, although they would have reinforced its messages. Also, the industrial focus is mostly on manufacturing, because it has received most official attention. But the analysis can be applied to other elements of industry, such as the primary and tertiary sectors, and to both the public and private sectors.

The writing of this paper began early in 2017, but circumstances have mitigated against its appearance until now. I was tempted to update it, but decided that the end of the story should be 2019, when a major government paper appeared, as did the COVID pandemic that upset how business was being done. The paper has been titled *Some Thoughts* to indicate that it by no means covers every aspect of the historical or technical subject matter, or every related incentive or other relevant federal program. So it is principally a historical review. I have also incorporated all four of the time periods used for the purposes of the main *150 Years of Canadian Engineering* paper's discussion*,* each having its own

development characteristics with regard to Canadian engineering: pre-1867; 1867-1918; 1919-1945: and 1946-2017.

In a nutshell, I first defined my thoughts on S&T and R&D in a report, *Science, Technology and Innovation,* published as Special Study No. 8 by the Economic Council of Canada in May 1968. This report implied, for example, that:

> (Science seeks) to discover, to demonstrate and to understand the laws of nature. (Technology seeks) to adapt scientific and other knowledge and experience for practical purposes. It is therefore technology, and not science, that has made possible the changes (that) have taken place in our (human) environment…Few inventions are capable of being made for the marketplace or the processing plant in (their) original forms.

Research and development are the *activities* that add to the bodies of science and technology. Research may also be divided into the basic, pure and curiosity-oriented kinds, and the applied kind, the former often being thought more difficult, interesting and prestigious to do, and the latter - sadly - less interesting, mundane, pedestrian and market-oriented.

**The four S&T and R&D Policy periods…**

Policies associated with S&T and R&D and engineering were not of concern to policymakers during the **first of the four time periods this paper covers** (pre-1867), although a number of Canadian public agencies - the Geological Survey, the Agricultural and Fisheries Departments, and the Board of Works - were established by the United Provinces after 1840 and did some research, gathered Information from abroad, supplemented by trial-and-error experimentation at home, were also practiced in the private/industry sector. There were very few scientists in the few universities, and few professional engineers in practice until around 1854, when the first university-level courses were given at the University of New Brunswick.

There *were* some policy concerns during **the second time period** (1867-1918). After 1867, the new Dominion government expanded its resource-based research activities and facilities that had been started by the United Provinces, and established some new institutions. Trial-and-error and reliance on new information from abroad continued in the growing private/industry engineering sector, whose manufacturing component benefitted from Macdonald's National Policy. The availability of university-level engineering courses continued to grow, especially after 1870.

However, during World War I, awareness of S&T and R&D and their potential grew rapidly in Government circles, influenced by British institutions. In 1916, the Government of Canada - under pressure from the British Colonial Secretary - established by Order-in-Council a National Research Council (NRC) or, more accurately, an Honorary Advisory Council for Scientific and Industrial Research.

Its initial job was to advise the Government on these matters. Its nine initial members, plus two others, were appointed in November i916, from the universities and industry. Professor A.B. Macallum from the University of Toronto was appointed full-time, paid chairman. As Eggleton noted in his history of the Council (1978), its's tasks were numerous and formidable. It was, for example, asked to organize, mobilize and encourage existing research agencies, to survey scientific and industrial research across the country, to coordinate such research as was being done, and to educate the public.

The Council first identified the status of research in Canada and established the need for more scientists and engineers. It voted to endow university scholarships from its own funds. It also set about convincing the public of the importance of research, examining what other similar countries were doing, and identifying the World War I problems requiring priority solution. In 1917 it established the first specialist Associate Committees of experts to examine specific areas or problems - a practice that has continued. Initially, the Council had no laboratories of its own and its discussions centred on industry and the universities… and on science and research rather than engineering and application. At least it got its own Act of Parliament, replacing the Order-in-Council!

NRC had expressed the view earlier that priority should be given to strengthening the universities' research, but had also decided to recommend that a central laboratory, serving mainly industry across the whole country, was still needed. This failed at first to get Cabinet's attention, but in 1919 the House of Commons established a committee, chaired by Hume Cronyn M.P., to investigate the need for scientific and industrial research in Canada, to which the NRC provided input. The committee recommended that a central laboratory should be established to support the discussive NRC, to do similar work to the U.S. Bureau of Standards and the public/private Mellon Institute in Pittsburgh, and to talk to American Public Service scientists and engineers about their experience.

**The third period, from 1919 to 1945,** which covered the relatively prosperous 20s, the depressed 30s, and the wartime early 40s, brought some expansion to the R&D facilities of the federal government and, to a lesser extent, to the largest provincial ones. It was also concerned by the large numbers of Canadian scientists leaving for work in the U.S.. But it was 1921 before a bill to establish an NRC laboratory was introduced, and it died sometime later in the Senate, in the maelstrom of contemporary postwar politics. As a result, the work of the Council suffered, as did the enthusiasm of its members. The Council had three chairmen in two years, until H.M. Tory took the chair in 1923.

Between the Wars, industrial R&D struggled to survive. A few of the universities did a little better, thanks to help from the NRC. By 1925, however, the Council, was doing some small-scale laboratory work under contract, with the most modest of resources and staff. But in 1932, with Tory still chairman, the Council finally opened its own laboratories in Ottawa, on Sussex Drive. (During World War II, more laboratories were added on Montréal Road.) Meanwhile, several federal departments had established or expanded their own laboratories, although this process was slowed by the Depression, but helped along by the drought being experienced across the Prairies.

The Depression measures proved to be of value during the rapid expansion of R&D activities in Canada during World War II, including NRC's participation in defence research and in nuclear research at the separate Montréal Laboratory, which was later transferred (in 1944-5) to Chalk River. Some provinces also expanded their R&D-performing and supporting agencies, including the Ontario Research Foundation and the Research Council of British Columbia. More progress was made, perhaps, in all sectors, during the six years of World War II, than during all the earlier years of this third time period. Several federal crown corporations were established temporarily in Ontario and Quebec to support aviation and other priority wartime manufacturing production, as was the chemical complex at Sarnia, Ontario.

**The fourth and last of the time periods, from 1945 until 2017,** was 'the one that changed the world.' The federal government's own scientific and technical activities continued to expand after World War II to include such new areas of activity as nuclear energy, pipelines and supplies from conventional energy sources, space hardware, synthetic chemicals, electronics and microelectronics. New agencies, such as Atomic Energy of Canada Limited, the Canadian Space Agency, and the Defence Research Board and its Communications off-shoots were established. The number of industrial R&D laboratories also expanded, as did the number of companies performing their own R&D. Advice was also forthcoming from the Royal Society of Canada…and the engineering profession.

This period also included the cancellation of the *Arrow* Project in February 1959 and the migration of hundreds of the engineers involved to the United States.

During this fourth time period, the study of S&T and R&D policies was formalized, blossomed and became the concern of many countries around the world, led initially by the United States and Japan, and sustained statistically over the years by OECD and its predecessors, based in Paris. These organizations and their consultants generated and examined S&T and R&D statistics, their 'economics,' and recommended policies to member countries. These policies also evolved into studies by academic professors in the United States and elsewhere, and much of the original policy emphasis was later transferred to innovation, productivity and economic growth calculations (see Cedargrove paper #60/2022), as well as to the search for workable new national and sectoral policies by countries and by individual institutions. Engineering figures were not featured, although patent ones were.

Also during this period, the engineering profession sponsored several committee-type initiatives in R&D, S&T areas, mostly managed by the Engineering Institute (EIC) and the Canadian Council of

Professional Engineers (CCPE-now Engineers Canada) - for example: CCPE sponsored regular information exchanges with the federal Government under the umbrella of its Canadian Engineering Manpower Council (CEMC), in addition to sponsoring a national conference in 1977 on engineering manpower planning; from 1980 to 1992 there was a formal Committee of Parliamentarians, Scientists and Engineers (COPSE) which held regular meetings with M.P.'s, some of which ended with dinners sponsored by the Speaker of the Senate; from 1982 to 1986, there was an EIC Committee for Federal

Government Liaison; and between 1987 and 1988 a short-lived Action Committee of Science and Technology Presidents (ACSTP).

In June 1995, the Partnership Group for Science and Engineering (PAGSE) was established by NSERC to allow technical societies to give regular advice to Parliamentarians, through the House Standing Committee on Finance "about recent advances in science and engineering." Its membership has been drawn from 25 national organizations, representing 50,000 members of the industry, academic and Government sectors. It has met for regular monthly breakfasts. Its principal preoccupation has been with research and development expenditures, subjects and priorities and its discussions of engineering have been marginal.

**Changes to Federal Departments and Agencies…**

Concern for the effectiveness of Canadian expenditures on S&T and R&D, and the dissemination of the results, began early post-World War II. NRC's activities were expanded. In 1947, for example, a Division of Building Research (DBR) was established to help develop a Canadian Building Code and to perform R&D whose results could be passed into, and used by, the building and construction industries. The Department of Reconstruction and Supply (headed by the Hon. C.D. Howe, an engineer) began a technical information service for the benefit of industry. A Defence Research Board (DRB) was established separately from NRC, to continue and expand the wartime defence research done by the Council.

In 1948, the NRC established Canadian Patents and Development Ltd. (CPDL) to handle patent and licencing matters on behalf of staff in all Government departments, agencies and laboratories. NRC also established a library which, in 1956, became the *National Science Library.* In 1960 a Medical Research Council (MRC) was established to further develop medical research in the universities. Around this time, also, the Diefenbaker Government established the National Productivity Council (NPC), with a mandate to explore and improve R&D as well as productivity and technical information dissemination at the engineering/plant level in Canadian manufacturing industry.

During the early 1960s, a special policy report was commissioned by Prime Minister Pearson from Dr C.J. Mackenzie, NRC's president during World War II, and the Atomic Energy Control Board's (AECB's) after it.

6The Economic Council of Canada (ECC) was established in late 1963 by the Pearson Government to replace the Conservatives' National Productivity Council (NPC), which retained its remit to study industrial research performance and technical information dissemination. Productivity, as such, was included in this remit, but since economists look on productivity differently from industry managers, their 'calculation' view predominated, and so the NPC's initial work on productivity at the engineering/plant level was mostly discontinued. The ECC also set up an Advisory Committee on

Industrial Research and Technology (of which Dr. Mackenzie was a member). Although its interest in science policy was short-lived, it reported that by 'international standards' the federal Government was doing too much R&D and industry, in spite of recently established incentive programs that included a tax incentive, was doing too little. So it recommended in a separate report how this might be changed. But the Government, led by the Minister of Finance, the Hon. Walter Gordon, decided otherwise.

By 1964, following the Mackenzie recommendations, a Science Secretariat had been established in the Privy Council Office, and a Science Adviser to the Cabinet appointed (first, engineer Professor Frank A. Forward and, later, engineer Professor R.J. Uffen). Also, an independent, advisory Science Council of Canada, (SCC) modelled on the new Economic Council, was established in 1966, to be led initially by medical doctor Omond Solandt, who had earlier led the new Defence Research Board.

In the later 1960S, a Special Committee on Science Policy was established by the Senate, led by Senator Maurice Lamontagne, who was an economist. It held a great many hearings and published four reports. As a result, some Canadians with political interests began to hear a lot more about science policy. Incidentally, this Committee of a dozen or so senators included only one engineer, whose attendance record was spotty, and no scientists. It was discontinued in 1977.

In 1971, Prime Minister Pierre Trudeau created another of his Ministries of State, this one for Science and Technology (MOSST), headed by the Hon. Alastair Gillespie, as the first Minister of Science. As noted above, MOSST acquired its initial staff from the PCO's Science Secretariat, which had earlier (1968) provided the new Science Council with its separate staff when it became a Crown Corporation. .

The number of universities and colleges in Canada increased significantly in the postwar years. For a long time NRC, with help from other agencies, had administered federal funding in support of university research, but in 1978 this job was re-assigned to three new institutions: one for the natural sciences and engineering research (note that *engineering* was specifically mentioned!), one for medical research, and the third for research in the social sciences and humanities.

In 1987 engineering celebrated its Centennial as a profession in Canada and this was marked by the Government in several ways, including the issuing of a commemorative postage stamp, the participation of the Governor-General and the Prime Minister in several events, and the identification of ten outstanding engineering accomplishments of the century.

Also that year, an independent, professional Canadian Academy of Engineering (CAE) was established, joining the Engineering Institute and its member societies and other learned ones, and the provincial (licensing) associations in representing the profession in public. The Canadian Academy also joined the growing number of such Academies world=wide. In 2005, the CAE joined with the Royal Society of Canada and the Canadian Academy of Health Sciences to form the Council of Canadian Academies (CCA), which has since issued several expert reports on S&T and R&D policies and many other subjects.

MOSST was abolished in 1990. Cabinet-wise, it was replaced by two portfolios: a Minister of Industry,

Science & Technology (MIST), the old Ministry of Industry, Trade & Commerce (MITC with a Minister of Science to assist him with regard to basic research.

The assumed S&T/R&D expenditures connection to GDP has continued to receive attention. Perhaps the difficulty here lies in the economists' wish to demonstrate that, for every extra dollar spent on R&D, the GDP and labour productivity and other economic measures will also benefit - directly and significantly = from increasing expenditures on R&D, S&T. In other words, they will be always good investments!

Note to the reader: From 1990 and for most of the next 25 years, the federal Minister(s) for Science and Technology changed regularly, changed their titles and responsibilities - all with relatively little apparent effect on the politics - as the Liberals and Conservatives changed as the ruling parties. Besides, each incoming Government also promised to improve the effectiveness of the policies for the better! So from this point in the narrative, until the arrival in power of Justin Trudeau as Prime Minister in 2015, the story of who was "Science Minister," under which Prime Minister, for how long, and what they may have done in the portfolio, becomes both complicated and confusing. And although I have mentioned a few of them in what follows, I am omitting most of the details. Instead, I would recommend that readers who wish to see them should refer to the reports, websites etc. included in the **Sources,** below…..

**New Incentive Programs…**

The 1960s also saw the introduction by the federal Government of a series of programs/measures/subsidies designed to increase the level and effectiveness of industrial R&D expenditures. The first was the cost-shared, conditional grant, the Defence Industrial Research (DIR) Program, established in 1961 and administered by the Defence Research Board. Early in 1962 its 'civilian' equivalent - the Industrial Research Assistance Program (IRAP) - was in place, administered by NRC. About the same time, a tax-based general incentive program was made available under Section 72A of the Income Tax Act for taxation years 1962 through 1966. The Program for the Advancement of Industrial Technology (PAIT) was established in 1965 as a grant/loan program designed to upgrade (civilian) industrial technology, competence and innovative capacity, and was administered by the Department of Industry, Trade and Commerce (DITC). The Industrial Research and Development Incentives Act (IRDIA) was passed in 1967. It was a grant-based general incentive program that replaced the Section 72A program, although benefits under it could also be taken as tax credits. In 1968 the cost-shared, grant-based Defence Industrial Productivity Program (DIPP) was established to replace the earlier defence assistance program. It was administered by DITC, and was the defence counterpart of, the PAIT Program.

Some of the provinces also introduced incentive programs similar to the federal models. Some of them established their own S&T policy advisory groups, boards and committees, as well as expanding their own technical activities. And more of them

opened industry-supporting laboratories on the earlier Ontario and B.C. Research Council models mentioned above. A few provinces have introduced tax-based R&D incentive programs.

IRDIA was repealed in 1975. Two years later the federal government introduced another industrial R&D tax credit (scientific research and experimental development - SR&ED) whose benefits were dependent on the companies and the regions of the country to which it was being applied. A year later the basic tax credit was raised regionally and for small businesses. However, as the result of abuses of the program, certain changes were made in 1983. Also that year a scientific tax credit was made available to companies undertaking research contracts for outside investors. In 1985 the eligible expenditures for the tax credit were again changed – significantly. More changes were made to the provisions and rules for this program over the next dozen years. However, concerns about the program were constantly being expressed, and the critics included the Auditor General. By December 2012 there had been a policy review of the program.

These incentive programs have been constantly modified over the years, and most no longer exist, the exceptions being IRAP and SR&ED During its lifetime, the Science Council reported its generally negative views on their effectiveness.

As part of a large re-alignment of government agencies, Prime Minister Mulroney abolished the Science Council, in 1992, and after its 26 years of service and numerous reports to the Government. The Economic Council was also abolished at this time.

In early 1993 the Liberals again formed the government, under Jean Chrétien, and established a Ministry of State for Science, Research and Development (MSSRD), which lasted for a decade under five ministers, none of whom had engineering or scientific backgrounds. Again, they essentially and officially, assisted the Ministers of Industry. The secretary/deputy minister of MSSRD became the *de facto* Chief Science Adviser to the PM and the Cabinet. MSSRD had oversight of federal S&T, R&D policy development and administration, but no budgetary responsibilities in regard to the performing departments and agencies.

Federal politicians would occasionally debate bills and motions that had some relevance for S&T and R&D policies in the House of Commons and, occasionally, during the 1970s, the House would, at the Opposition's behest, hold one-day debates on science policy. These debates were usually reported in technical society periodicals.

As noted above, the Council of Canadian Academies (CCA) was formed in 2005 by the Royal Society, the Academy of Engineering, and the Academy of Health Sciences. It has since produced several reports on S&T, R&D, and has completed a number of expert studies, including ones on: Improving Innovation through Better Management; Building Excellence; From Research to Reality; and Powering Discovery.

Over the past two decades (1995-2016) there has actually been a succession of advisory bodies established and reports specially written to provide science-based advice to the federal Government.

For example, In her recent British book (2015), *The Entrepreneurial State,* Mariana Mazzucato drew attention to the historic role of the U.S. State - as the main funder of basic research, through agencies such as DARPA - in the eventual development of disruptive innovations/technologies by private industry. Canada has had no equivalent of DARPA, although the idea has received some support.

During the Martin administration, from 2003 to 2006, and first two years of the Harper administration, no Cabinet minister, beyond the Minister of Industry, had formal responsibility for S&T or R&D policies. Between 2008 and 2015, Prime Minister Harper appointed three Ministers of State for Science and Technology, again to assist the Minister of Industry.

**Studies and Reports…**

The process of highlighting science and research in general and in print may have begun in earnest with the publication of Vannevar Bush's book *Science: The Endless Frontier* in 1945. It was brought to the attention of the president of the United States. In the years that followed, names such as Derek de Solla Price, Harvey Brooks, Zvi Griliches, Donald Schon, Richard Nelson, Edwin Mansfield and Christopher Freeman became associated with this new academic research field, and well-known internationally. Conferences, seminars and meetings were held, principally in the U.S., Britain and France. And the literature grew quickly. In Canada, the Economic, Science and National Research Councils became involved. In retrospect, however, it should be noted that many of the well-known people in the field internationally had backgrounds in economics and the social sciences, or came from 'basic/pure' specialized research laboratories. In other words, many of the science advisers were in fact limited in their experience of applied science, its activities and disciplines. They were most familiar with their own, and in competitive terms.

Almost without exception, the published domestic and foreign studies and reports that included Canadian S&T and R&D statistics have appeared to praise Canadian aggregate contributions in the University and Government sectors, and to criticise those made by/for the Industry sector as inadequate, usually without fully recognizing why any of them were, or were not, being made. Industrial R&D may be done without an immediately *confirmable* objective, but it is seldom done without an objective! But little is known about *engineering R&D, S&T.*

Late In 1967, the Science Council contracted out a background study on *Engineering Research in Canada.* Several years and at least two study leaders later, nothing much had been done. Eventually, a meeting was called by Chairman Solandt to decide what to do with this study. The decision was made to abandon it as presently organized and to turn over the material that had been collected to the Council's Committee on Industrial Research and Innovation. It never surfaced again. The problem in large part was that nobody in Canada (or elsewhere) had apparently collected statistics for their *engineering*

research or development. They had collected *applied research* figures for a variety of science disciplines, but these were not really helpful.

In 1968 the Science Council published its report No.4: *Towards a National Science Policy for Canada.* The Council said it was attempting to lay down broad guidelines for the future development of science and technology in Canada, that it was stressing the use of S&T and R&D policy in a comprehensive way, that the *application* of S&T and R&D would make significant contributions to the solution of economic and social problems, but that expenditures on them must compete with alternatives in the allocation of the nation's resources. The Council recommended the extension of what it called 'major programs' (such as for space, nuclear power and water resources) that would coordinate the efforts of all economic sectors in a multi-discipline way.

Initially, the Science Council's studies had been mainly about R&D in the individual performing disciplines of science. Included also, were studies of technical information dissemination and industrial R&D. It also identified two separate aspects of S&T policies: those for the *use* and *application* of science and technology, and those for the *use* of S&T *in the policies of Governments* and the work of their departments and agencies.

Over the rest of its life, until 1992, the Science Council looked into more general problems, such as, space S&T, transportation, pollution, the conserver society, energy use, development of the North, and innovation. It also promoted the idea that Canada should be technologically *sovereign* – an idea that did not find unanimous support.

One the forgotten reports about federal activities in support of Canadian science and technology was the one completed in July 1984 by the Task Force on Federal Policies and Programs for Technology Development. It was addressed to the Hon. Ed Lumley, Minister of State for Science and Technology in the Martin Liberal Government, who had requested it. The reason for the forgetfulness may well have been the change in governing party that took place shortly after the report was presented.

Its primary conclusion was that federal government policies and programs, generally, were not working well, some not at all. It went on to say that, since technology was at the heart of Canada's well-being, any federal government must prioritize the need to manage activities associated with it, and that it should set a climate that encouraged the private sector to adapt and use the world's technologies and create new ones that responded to market opportunities for Canadian firms.

Its recommendations included the directive that the federal Government's involvement in technology should maximize the market's 'pull' on the innovation process, that responsibility for actively supporting technology development should be made explicit in departmental and agency mandates, and the chief science advisor should report regularly to the prime minister on technology development issues. The

impact of technological innovation on employment and working conditions should receive the attention it deserves from researchers and policy-makers, in order to bring labour and management closer together in productive enterprises. As well, existing industry support programs should be reviewed, as should the operative definition of "R&D, and a number of specific changes implemented. The government's purchasing power should be used mandated to promote private sector innovation. The role of NSERC in support of university research should be reviewed and it should coordinate all federally supported R&D in these institutions. The Panel also criticized the management of federal laboratories, the lack of review of their roles in relation to the private sector and the need for more of the government's requirements to be contracted out.

Thanks largely to OECD, international R&D statistics have been collected regularly around the world for comparative purposes, one result of which has been constant criticism of Canada's position in the international science policy 'league tables.' But were they accurate? Opinions differed. And thanks largely to the views of many of the pure/basic scientists (like Alexander King, of OECD), a direct connection was at first being assumed between 'basic research' in science…and innovation. But as, King wrote in his 2006 autobiography:

> When it came to technical rather than scientific information, I came to appreciate the depth of my own ignorance. I had shared the naïve assumption of many basic science researchers that technological advances arise from an entrepreneur becoming aware of the potentiality of a discovery in pure research and transforming it into a commercial product through rather pedestrian applied research. I was quite unaware of the thousands of small technical advances that contribute to ever-advancing technologies. I had given little heed to the importance of know-how and still less to how it was disseminated.

How much difference Alexander King's change of view had on the science policy studies at OECD and elsewhere is not immediately known. But King was by no means the only one holding such views. The 1986 Report of the (Canadian) National Technology Policy Roundtable noted:

> The innovation process involves a continuum of activities that are interlinked: no link in the chain can exist for long in isolation.
>
> The process begins with the conduct of basic science. Market research then filters out the products or ideas that might be transferred into commercially viable products at the applied research stage.

And everyone in the S&T and R&D businesses was, apparently, a *scientist.*

This is perhaps the place to spell out one of the main reasons why the word *engineering* was lost in policy discussions, at a time when, in terms of members, the professional science and engineering communities in Canada were about the same size. But the powers that be (OECD, or the U.S. experts?) having determined that *engineering* should be part of science, the word was no longer used - and it mostly disappeared. (An exception in Canada was the Natural Sciences and Engineering Research Council, NSERC). So, for many years, *science and research, science and technology,* were the watchwords/buzzwords. And this also applied in later years, when a new watchword/buzzword appeared….*innovation.*

Unfortunately, using the shorthand of the day, the word *technology* also went missing from a lot of formal statements although, with time, it came to be used again more frequently and appropriately.

**More Recently - mostly 2015-2019…**

Following the Liberals' general election win in October 2015, Prime Minister Justin Trudeau appointed *two* science ministers: one, a Minister of Innovation, Science and Economic Development (MISED), the Hon. Navdeep Bains, an accountant, who would have been the Minister of Industry in earlier administrations, his role being essentially to improve the economic and social well-being of Canadians, to encourage industrial research, and to improve Canada's innovation performance; two, a Minister of Science, the Hon. Kirsty Duncan, a scientist, to provide improved oversight of Canadian basic science and research. This minister was also tasked with appointing a Chief Science Adviser, which she did late in 2017 with the appointment to that post of Dr. Mona Nemer.

In June 2016 the federal Government, through the Minister of Science, appointed an Advisory Panel on Federal Support for Fundamental Science, with a mandate to review the federal system of support for extramural research conducted by scientists outside the federal, provincial and territorial departments and agencies. Its focus was on knowledge generation programs and not those encouraging partnerships with industry or promoting innovation and commercialization. The Panel's focus was on four federal agencies: the three federal granting agencies (NSERC, CIHR, SSHRC) and the Canadian Foundation for Innovation (CFI), as well as funding arrangements in peer nations. In addition to soliciting over 1,000 written submissions, the Panel convened roundtables in five cities.

Its report noted that Canada's Gross Expenditures on R&D (GERD) had been declining slowly over that last 15 years in comparison with other G7 countries and key Asian countries. However, the higher education component of Canadian expenditures (HERD) in 2014 was seventh in OECD and highest in G7. Also, in 2015, half of the HERD total was funded by the universities themselves, and only 23 per cent contributed by the federal Government. In the panel's view, this was detrimental to both Canadian research and education.

The Panel concluded, among other things, that Canada's 'federal research ecosystem' was weakly coordinated and inconsistently evaluated, that links between intramural and extramural research needed to be strengthened, as should federal/provincial collaboration. A Chief Science Advisor should be appointed (and was, in late 2017), and (yet another) National Advisory Council on Research and Innovation should be created! But nobody was examining how effective Advisory Councils and Panels actually were, although a (2016) paper by Quiron, Carty, Dufour and Jabr concluded that "science and science advisory systems in Canada have lacked continuity and a solid foundation, thus weakening efforts to transfer sound science-based policy into decision-making." The authors defined *science* to include the natural, social, engineering and applied sciences and technologies. Evidence that they considered engineering or engineering research, by themselves, is missing. On the other hand, they report that, as a result of a recent international meeting, an International Network for Government Science Advice had been established.

The OECD 'scoreboard' for science, technology and research for 2017 included the following information:

> Canada accounted for just over 3% of the world's top 10% of most-cited scientific publications in 2016, just behind Japan and France; data on international mobility of scientific authors for 2002 to 2016 shows that Canada has attracted more authors than it has lost. Canada accounted for 2% of Artificial Intelligence (AI)-related patent applications during 2010-2015, down from 2.4% in 2000-2005, and is the sixth largest producer of most-cited scientific documents on machine learning after the United States, China, India, the U.K. and Italy. Canada accounted for 0.9% of all AI-related inventions from 2012-2014. In Canada in 2015, R&D tax incentives accounted for 75% of overall support for business R&D; relative to the size of the economy, venture capital investments in Canada are the third-highest in OECD, at 0.16% of GDP, only behind the U.S. and Israel.

The 9th Canadian Science Policy Conference was held in Ottawa in November 2017. On paper, as a non-partisan forum for the discussion of science, technology and innovation, this 9th conference was titled *150 Years of Canadian Science and Innovation: How do we forge ahead.* But It discussed research almost exclusively. There were an estimated 700 delegates in attendance, and 200 speakers, including the new 29th Governor General of Canada - the Rt. Hon. Julie Payette - an engineer. It was organized and sponsored by a long and impressive list of Government, academic and industrial organizations. It became, in effect, a platform for the federal minister of science, the Hon. Kristy Duncan, and followed her recent appointment of a chief science adviser to the Government of Canada, Dr. Mona Nemer.

This was the *ninth* such conference. With regard to the previous eight, the program noted:

> The conference has been a platform to feature reports and projects from prominent organizations in science enterprise. It has become a major focal
>
> point for the science and innovation policy community to network, get engaged, and be heard on the most pressing science and innovation policy

In other words, this conference provided only a very limited view of the overall Canadian science policy issues.

In an interview reported in the December 2016 issue of the Globe & Mail's *Report on Business*, British author and economist Mariana Mazzucato answered the question *What is Canada doing right or wrong when it comes to research and development?* She said:

> Canada is skewed in two ways. It over-relies on indirect incentives for companies through different types of tax credits. And Canada skews it in terms of sectoral composition. So the areas of expertise, especially in terms of innovation and R&D spending, are in very few sectors. It's not distributed across the whole economy and it's too concentrated on the extractive area of the economy. And that would be fine as long as the profits generated from that area were being reinvested back into new potential opportunities of the future. But they're not. It's quite static and it's inertial…

In April 2017 an expert Panel submitted its review of fundamental science in Canada. Called the Naylor Report after its chairman, its members included eight academics. Only one of them had had extensive industrial experience (Mike Lazaridis, at RIM and BlackBerry, although his current preoccupation was with more fundamental science.) The Minister of Science, Dr. Kirsty Duncan, received the report.

The panel's principal recommendation was that the current advisory body in the field, the constrained Science and Technology Information Council (STIC) should be replaced by a National Advisory Council on Research and Innovation (NACRI), with 12 to 15 members, and connected to the Prime Minister's Office. It should provide 'broad oversight of the federal research and innovation ecosystems.' The responsibilities of this Council were also spelled out. It recommended that a Chief Science Advisor (CSA) should also be appointed. As of late 2017, there was a CSA, but no NACRI.

The panel found, for example, that gross domestic expenditures on R&D from all sources relative to GDP had been declining slowly over the past 15 years. It found that, in 2015, almost half of the R&D expenditures in the university sector had been funded by the universities themselves, and that the federal government contributed only 23 per cent, an anomalous situation internationally. It also found that independent research in the universities had declined between 2006 and 2014, although the number of university researchers had increased.

A Statistics Canada report published in June 2017 noted the following in regard to Canada's GERD:

in 2006, the GERD was $28,022 millions, and as a percentage of GDP was 1.99%

…in 2009, was $30,751 millions, and 1.87%

…in 2013, was $32,707 millions and 1.79%

…in 2015, was estimated at $31,825 millions and 1.61%

For 2010, the latest available year, these were the GERDs for selected countries: Israel, 4.5%; Japan 3.1%; USA 2.8%; OECD average 2.2%; Australia and France 2%; Russia 1.2%.

It is important to realize just how many billions in actual aggregate dollars spent that 2.8% of the United States' GDP represent. The U.S. performs annually something like 17 times as much R&D as Canada does. The multiplier for Japan is six, but, for France, it is only two. On the other hand, none of these aggregate figures tell us about their *potential* as expenditures supporting innovation. The real test in R&D expenditure comparisons, therefore, is not how much is spent, but *how much is being well spent, on what.* Throwing money at S&T, R&D does not, of itself, make the expenditures valuable!

The most recent addition to my collection of brochures about federal R&D programs is the massive 200-page catalogue of federal programs issued by MISED in February 2019, and called *Building a Nation of Innovators.* It is full of supportive comments by Government, industrial and academic people. It emphasises how important university and other *science* activities are in providing a portion of the new knowledge and highly-trained personnel needed to drive Canadian innovation. There was also a lot of information about the dollars the Government was/is spending to support industrial research and academic innovation. But of innovation itself, there was little discussion. Technology was mentioned sporadically, engineering hardly at all.

But after the General Election in late 2019, Trudeau abandoned the separate Science Ministry and changed the MIDED one to Innovation, Science and Industry (MISI). The relatively less-visible Minister Bains was succeeded in his portfolio, in another Liberal minority Government, by the Hon. F-P Champagne, a strong business/industry supporter and a much more visible and voluble politician.

Finally, it would appear that recent science policy and R&D discussions have become a little more 'comfortable.' Regardless of what the numbers may tell us, the newspapers are telling a more encouraging story. For example, we may have lost Nortel and BlackBerry, but we have won back MDA Associates and their Canadarm and satellite skills, and we have hung on to Shopify. Newspapers have been carrying full page advertisements for the S&T and R&D (and innovative) skills of certain universities. They have also carried articles about artificial intelligence and quantum computing, and stories about the allocation of larger and larger amounts of venture capital and the possibility we may now avoid the disappearance of our best new, small companies to the United States. The potential 'brain drain' to the U.S. has also been put in a better light. Silicon Valley is not quite so fearsomely competitive…or is it? We are rumoured to have a rival Silicon Valley North somewhere around

Waterloo, Ontario, or is it Ottawa, Ontario? Nevertheless, the engineering profession in Canada needs to become still more visible and effective. Its stories need to be told.

Recent science policy discussions in Canada appear to have been dominated by basic research scientists from academia. Academic engineers have on occasions been included, but seldom have the numbers of those with industrial engineering training, backgrounds and experience risen above a very few.

With the exception of the *Science Council, the PCO and MOSST, the idea that basic research will lead to industrial innovation has* been consistently championed by policy discussants and its actual application in Canada (rather than the United States) over-emphasized. OECD has been of little help. Federal politicians have never really contributed to this particular debate.

*Science* policies, but not *technology* policies, *basic* (or curiosity-oriented) research but not engineering/technological *development,* have been the foci of Canadian discussions. On the other hand, perhaps the councils, committees and discussions did a great job for *science* after all. The important result of it was not that valuable *Canadian* innovations were the result, but that Canadians were trained and became expert in the subject matter and could provide interpretation and advice on what was being done on it elsewhere in the world.

Finally, by 2019 the casual Canadian observer may have been conscious of fewer public discussions of S&T policy and R&D statistics.

**In Conclusion…**

It would seem that…

We do not yet have a policy structure for S&T, R&D that works well enough (and especially if innovation is added to the mix). It simply may not be possible with our federal structure. On the other hand, Canadian industry has not yet admitted that Government is capable of making project decisions and perhaps should be admitted to project content decisions.

Nor do we yet have meaningful numbers that would assist us in making meaningful international comparisons, if such would really help in designing our S&T, R&D policies.

Engineering comes after S&T, R&D in the 'production process' (and may even be part of it. Its place and functions need to be re-examined.

Generally, too few Cabinet Ministers have qualifications and experience to make better science policy- and engineering-dependent decisions. Question: Should the Cabinet have a Chief Engineer (with some staff), and will today's C.D. Howe please get himself elected!

**Sources…**

Many of the Sources have already been identified in the text. A few others are:

Economic Council of Canada, *A general incentive program to encourage research and development in Canadian Industry,* December1965

Andrew H. Wilson, *Governments and Innovation: Background Study for the Science Council of Canada,* Special Study No. 26, April 1973

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Alexander King, *Let the cat turn around: One Man's Traverse of the 20th Century,* CPTM, London, 2006

Annual and other National S&T, R&D Statistical Reports by OECD and Statistics Canada, the National Productivity, the Economic and the Science Councils of Canada

https://en.wikipedia.org/wiki/Minister_for_Science_(Canada)

The accompanying 'innovation' paper (Cedargrove #60/2022) has more to add to the above list.

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