First Interim Evaluation of the NextGen Biofuels Fund™

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I INTRODUCTION

A. THE FOUNDATION

The Government of Canada created and financed a foundation, Sustainable Development Technology Canada (SDTC) to "act as the primary catalyst in building a sustainable development technology infrastructure in Canada." The Act establishing the foundation came into force on 22 March, 2002 (Minister of Justice, 2002). SDTC operates at arms-length from government under the guidance of a Board of Directors, a majority of whom are drawn from the private sector. The foundation reports to Parliament through the Minister of Natural Resources and maintains a working relationship with Natural Resources Canada and Environment Canada.

At about that time, Canada and the Foundation established the Sustainable Development Technology Fund (SD Tech Fund) to support demonstration projects for new sustainable development technologies that address climate change and clean air, clean water and clean soil.

B. THE NEXTGEN BIOFUELS FUND™

In September 2007, the Government of Canada signed a Funding Agreement with Sustainable Development Technology Canada that established the $500 million NextGen Biofuels Fund™ (NGBF). The agreement sets out the purpose of the Fund in these terms:

> "(a) facilitate the establishment of First-of-Kind Large Demonstration-scale facilities for the production of Next-generation Renewable Fuels and Co-products;
> (b) improve the Sustainable Development Impacts arising from the production and use of Renewable Fuels in Canada; and
> (c) encourage retention and growth of technology expertise and innovation capacity for the production of Next-generation Renewable Fuels in Canada." (SDTC, 2007)

The Funding Agreement specifies that three interim evaluations should be conducted, made public and submitted to the Government of Canada. They will be conducted at five year intervals with due dates of November 30, 2012, 2017 and 2022. The agreement specifies the scope of the interim evaluations:

> "These interim evaluations will focus on the administration of the Fund and provide commentary on the overall operation of the Foundation in meeting the purposes of the Fund as outlined in Section 2.01, including an evaluation of the Sustainable Development Impacts and Market Impacts of Funded Projects as estimated as of the date of the evaluation. In addition, the interim evaluation will provide commentary on the Foundation's reinvestment and repayment collection experience. The Foundation will respond to the findings by making the adjustments consistent with (the Funding) Agreement that it considers necessary and make these adjustments known to Canada." (SDTC, 2007, Section 12.11).

C. THIS REPORT

This report responds to the requirement for the First Interim Evaluation. The following chapter provides a summary of the evaluation. Subsequent chapters outline the approach and methods, and address the key issues for the evaluation, the relevance of the Fund, its operations and a projection at this early stage in its work of the projected outcomes of the Fund including a projection of the value to Canada resulting from the biofuel projects that are being developed with the Fund's support.

II HIGHLIGHTS OF THE REPORT

A. THE EVALUATION

We reviewed the project plan for this study with an Advisory Panel made up of representatives from the two oversight departments, Natural Resources Canada and Environment Canada. The panel reviewed the plan before it was implemented so they could offer comments or suggestions that would help the evaluator to focus on issues of importance to the departments. The study responds to the evaluation plan and to the panel's input.

The evaluation relies on an extensive review of the related literature, examination of the records and operating documents including submissions to the SDTC Board and submissions to the Fund by project proponents. We conducted 37 personal interviews, 14 with proponents and senior members of project teams, eight with officials of other government departments and the balance with investment specialists, officials from similar programs in other jurisdictions and others with a sector-wide perspective.

B. RELEVANCE

The Fund is one of four pillars of Canada's Renewable Fuels Strategy (RFS) which was announced in 2007:

- **Increase the retail availability of renewable fuels through regulation.** Federal regulation requires 5% renewable fuels content in gasoline and 2% in diesel and heating oil.
- **Assist farmers to seize new opportunities in the renewable fuels sector.** The ecoAgriculture Biofuels Capital Initiative (ecoABC), a $200 million program that provides repayable contributions for construction or expansion of transportation biofuels facilities.
- **Accelerate the commercialization of new technologies.** The $500M NextGen Biofuels Fund™ is aimed at supporting the establishment of first-of-kind commercial scale demonstration facilities for the production of next-generation renewable fuels and co-products.
- **Support the expansion of Canadian production of renewable fuels.** To stimulate domestic biofuels production, Natural Resources Canada established ecoEnergy for Biofuels (ecoEBF) to provide up to $1.5 billion of operating incentives to biofuel plants in the period from fiscal year 2008-09 to 2016-17.

Our review indicates that as one of four pillars of the Renewable Fuels Strategy, the Fund's relevance is confirmed. The Strategy remains government policy and the other three pillars are either operational or completed. We did not identify any significant overlap with

other programs. Providing support to encourage the development of new technologies is an accepted role of the federal government.

The need for the Fund is unquestioned among all key informants. The changes since 2007 in the economy and in financial markets have made the Fund's support even more critical than it was when the Strategy was announced. Interview respondents voiced strong support for the role it is playing in the development of next-generation biofuels in Canada.

C. PERFORMANCE OF THE FUND

1. Project Management and Commitment of Funds

The Fund requires that all projects follow the 'stage gate' project management approach, the industry standard when dealing with large complex capital projects such as are supported by the NGBF. Some interview respondents were critical of this approach, expressing concern that it was unduly bureaucratic, increased the work required to advance a project and introduced delays in the process. We found that the majority of proponents who are currently working with the Fund already use this approach. The Fund allows them to follow their internal procedures, modified as necessary to accommodate performance indicators required by the Fund. If the proponent does not have an established approach to stage gate project management, the Fund has outlined a version it calls the Project Assurance Process (PAP), which projects must follow.

A central principle of the approach is risk mitigation. As project plans are developed, project partners examine them at five stages in the process. The review examines all aspects of the project plans to identify risks or weaknesses. The examination is extensive and thorough, stretching from performance of the technology and process design to financial structure and projected internal rates of return, environmental permits, site considerations, arrangements for feedstock supply and sale of the plant's output, etc. If risks or weaknesses are found, the team may modify the plans to reduce or eliminate the issue. Then, given the findings of the review, project partners make a 'go/no go' decision on proceeding to the next phase in the project development. If the decision is 'go', partners release the funds to support the costs of the next phase. Project partners withhold the final approval, the Final Investment Decision (FID), until the final decision gate. Only when the project passes the final decision gate with complete and final plans for each aspect of the project do the partners release the full funds for construction.

The timing of the FID has had significant consequences for the Fund. For support of this type, the usual approach in government is to hold a competition, review proposals and announce winners. In the stage gate process, the competition is about the equivalent of gate 1 or perhaps gate 2 of the five gates. As a result, while NGBF projects are working toward construction, well past the time when announcements of approval are typically made, the Fund has been silent. To a casual observer, it appears the Fund has made no progress.

Our research confirmed that the stage gate approach is widely accepted. It has been featured at recent biofuels conferences and is used by the biorefinery program of the US Department of Energy.

In our view, the record of the stage gate approach clearly justifies its use by the NGBF.

2. Investment Strategy

The Fund developed a business case to guide its development. It scanned the biofuels sector, describing its complexity, and laying out an approach for the Fund that integrated the requirements of the Funding Agreement with the realities of the sector. It highlighted Canada's vast supply of feedstocks for next-generation fuels. For example, employing just wood waste, agricultural residue, municipal solid waste and manure, Canada could support the equivalent of 120 world class biorefineries capable of producing 25 times the Canadian RFS increment to 2034. The business case identified two significant challenges posed by the Funding Agreement and the Canadian policy environment:

- **Financial performance.** NGBF projects must show acceptable financial performance without any subsidy or support beyond the contribution from the Fund. This is a more stringent test than was faced by proposals for Canadian grain ethanol plants that benefit from the production subsidy provided by the ecoEBF program (which is now closed so is not available to the NGBF projects) or the next-generation biofuels projects being supported by the US Department of Energy that are supported by segregated fuel standards for next-generation fuels and a variety of other capital and operating support programs.
- **Challenging, and moving, targets.** Proposals to the Fund must have the potential to demonstrate that the technology can achieve better emission reduction and lower cost than first-generation fuels.

The Fund identified the most promising candidates to develop projects. It assembled a list of all organizations in the sector and applied a series of screens to select those sufficiently advanced to develop a commercial project that would satisfy the Fund's selection criteria. The Fund maintains contact with the leading candidates.

Our review of the strategy confirmed the Fund's approach to seek broad coverage of the technologies in the sector, judging that it is too early to 'pick winners.' While a few commentators expressed reservations about the characteristics of projects under development, proponents were strongly supportive of the Fund's approach, developing projects that satisfy project partners' criteria and minimizing any identified risks to the project.

3. Operation of the Fund

i) Awareness

Since its inception, the Fund has been active in the biofuels community. Internal records show that it has been in contact with virtually all the organizations in the community. We suggest that it should maintain its visibility in the community so that any new entrants will be aware of the NGBF.

ii) Interaction with Project Proponents

The Fund gets high marks for its role as an active investor from all who have knowledge of the Fund's activities. In particular, proponents strongly supported its approach. The Fund works actively with proponents to facilitate their projects. It does not impose delays. The rate of progress is determined by the proponent. It actively participates in the decisions to support a project. To date, all decisions to delay or withdraw a project were initiated by project partners, not by the Fund.

4. Achievement of Expected Outcomes

i) Progress to Date

As noted above, the Fund has not announced support for any project since the 2008 announcement for Iogen, so the perception has emerged that it has made no progress. The evaluation found this is not the case. The Funding Agreement charges the SDTC Board of Directors to exercise its discretion to support proposals of greatest merit. Since its inception, the Fund has worked with a number of proponents to develop potential projects. To date, 17 of those projects, representing about $1.6 billion in potential contributions from the Fund ($6.1 billion total investment), have been brought to the attention of the Board of Directors.

As this report is written, three projects whose potential commitments total about $297 million, have completed the due diligence review of their Application for Funding (AFF) and were approved by the SDTC Board for support to complete the Project Assurance Process. A further two projects ($170 million potential commitments) have filed AFFs. One due diligence has been completed and the findings are scheduled to be presented to the Board in November 2012. The second is scheduled for the Board meeting in the 2nd quarter of 2013. The potential commitments for the five plants account for the total investment available from the Fund. Should any of the projects not proceed or be down-sized, a further group of three proponents, whose potential projects representing potential commitments of $380 million, have submitted Indications of Interest and are in active discussions with the Fund to develop their projects. They represent potential candidates to move ahead in the process, taking the place of any project that encounters difficulties. In other words, the Fund has followed the directions of the Funding Agreement and created a pipeline of projects that satisfy its requirements. The projects represent funding support requests equal to the amount provided by the Agreement and current plans show disbursement to those projects will be completed in advance of the deadline set out in the Agreement.

Given that the Fund's progress was identified as a concern, we sought comparisons that might provide a context for judgments about progress to date. The only comparators we could identify in Canada were Natural Resource Canada's Ethanol Expansion Program and Agriculture and Agrifood Canada's ecoABC program that supported the expansion of Canada's capacity to produce first-generation biofuels. These comparison are weak because those programs worked within the overall budget framework of their departments so progress against budget deadlines is far less stringent a test than completion of disbursement by a deadline established in a legal agreement with an arm's length agency. In any case, we conclude that the progress shown to date by the NGBF is generally in line with that recorded by the two Canadian programs.

The only close comparator is the US Department of Energy's Biorefinery program, which was mandated in 2006, about a year before the NGBF was established. This comparison is overshadowed by the considerable supports available in the United States, including two loan guarantee programs, segregated fuel standards for next-generation biofuels, tax incentives that create production subsidies for fuel produced and a floor price for the product. These supports substantially reduced the risks faced by the Biorefinery projects: financing risk was reduced by the availability of guaranteed debt financing; financial performance risk was reduced by production subsidies that provided an additional income flow; and market risk was effectively eliminated by the fuel standard that created a market demand for the product. In contrast, the NGBF is the federal government's only support for next-generation biofuels. So compared to the projects supported by the Biorefinery Program, the NGBF projects face elevated risk in each of these areas.

On first glance, it appears that the NGBF has achieved about the same progress as the DOE biorefinery program. Both invested about the same amount in capital supports and both are working toward completion of five projects. However in our view, a closer examination indicates that the comparison favours the NGBF. The DOE program conducted a competition and in 2007 selected six proposals for commercial-scale biorefineries. Three are no longer active, one of which was cancelled in the midst of construction. The first DOE plant is scheduled to begin commissioning in the next few months, so taking into account the earlier start of the DOE program, the DOE plant is about a year ahead of the first NGBF plant. The second DOE plant is in a similar stage to the three leading NGBF projects, completing detailed design and not yet passed FID so not yet released for construction. The last surviving DOE project from the 2007 biorefinery competition is dormant while the proponent seeks a strategic investor. The DOE program counts as biorefineries two projects originally funded as demonstrations (roughly comparable to biofuel projects supported by the SD Tech Fund) so the program now reports a total of five biorefinery projects. Given these details, we judge that the progress achieved to date by the NGBF compares favourably to that of the DOE's biorefinery program.

Overall, we conclude that the NGBF has made remarkable progress toward its goal of facilitating the establishment of next-generation biofuel plants in Canada. It has exercised the discretion provided in the Funding Agreement to avoid investments in projects it judged to be not yet project-ready and has created a pipeline of projects that are moving toward completion. Current estimates indicate that the first five projects will account for all the available capital funds from the NGBF and those funds will be disbursed before the Agreement's deadline. Should any of the first five NGBF projects fail in the next months, three other proponents are available to replace them. All of this has been accomplished by the NGBF as the sole federal support for next-generation biofuels. In our judgment, this progress compares favourably with that achieved by the DOE biorefinery program, which has been able to count on an array of generous capital and marketplace supports.

Our review suggests that the Fund's unfavourable image results from the absence of public announcements of awards to projects. Our analysis suggests that if the Fund had followed the typical approach taken by government, announcing a competition and funding winners, it would have announced full funding to at least three of the currently active projects. However the Fund chose to follow the industry best practice for development of projects of this type and used the more conservative PAP which does not commit funds for construction until all aspects of the

project plans are final. The absence of announcements has created a false impression that the Fund has not made progress.

ii) Sustainable Development and Market Impacts of the NGBF

The Funding Agreement for the NGBF specifies that the interim evaluations should include an estimation of the Sustainable Development Impacts and Market Impacts of Funded Projects as of the date of the evaluation. We respond to this requirement by presenting a cost-benefit analysis of the five projects currently engaged in the Project Assurance Process, moving toward Final Investment Decisions to authorize construction to begin. These projects will require the full amount of the investment funds available from the Fund so they represent the impact of the full deployment of the Fund.

Considering just the five first-of-kind plants, we assume they will generate no private returns beyond paying back the initial capital cost. On this basis we estimate the total net benefits to society at $218 million. We assume that on average, each project will generate two follow-on plants in Canada, far fewer than projected by the five projects. Using very conservative assumptions, no productivity improvements or economies of scale for the subsequent plants, the total social benefits for the first and follow-on plants are in the order of $1.4 billion.

There is a high degree of uncertainty inherent in the sales and GHG emission reductions forecasts, so our cost-benefit results should be treated with some caution. However, after conducting a sensitivity analysis, we find that overall, including the most pessimistic scenario, the results support the view that the total social benefits outweigh total costs for the projects. In other words, the NGBF represents a significant net benefit to Canada.

5. Suggestions for Improvement

Our review has identified some aspects of the Fund that warrant attention and possible improvement:

- Work to improve information sharing between departments and the Fund. Departments note that the arm's length relationship of the Fund means the department suffers from a lack of information about the biofuels sector. Government departments could benefit from the detailed understanding of the biofuels sector that the NGBF has developed. We suggest the departments and the Fund should work toward a more open relationship that would allow departments to draw upon the Fund's unequalled expertise in biofuels. For example, the departments could invite the Fund to provide input on questions that arise about the sector, perhaps invite the Fund to participate, as a resource, in policy discussions that include consideration of the biofuels sector.
- Address proponents' concerns about possible delays in decisions by the Fund at stage gates. The concern is largely hypothetical, but addressing it at this stage would remove it from consideration.
- Consider approaches that could provide proponents with more clarity about the repayment conditions and earlier confirmation of the amount of support that will be

provided by the Fund if the project passes its FID. Both these factors must be taken into consideration in the planning and approval process but under current approaches, the arrangements are not finalized until the project is at FID.

- Consider ways of addressing the lack of awareness or understanding of its progress.

III METHODS

A. EVALUATION PLAN

1. Developing the Evaluation Plan

In accordance with the Funding Agreement, the Fund developed an evaluation plan that outlined the overall approach to the four evaluations required by the agreement. The plan was accepted by the Board of Directors in 2008.

The general approach and detailed plans for this evaluation were developed in two steps.

- Following the approach outlined in the evaluation framework, the evaluation team developed a detailed planning document for this project.
- In support of the planning for this evaluation, the Foundation established an Advisory Panel comprised of officials of Natural Resources Canada and Environment Canada. The evaluation report is a major accountability document that will be submitted to the two departments. In the view of the Fund, the report should not only follow the approach set out in the framework study, it should also respond to the issues and questions of interest to the departments that could be addressed by the evaluation. Accordingly, the Foundation hosted a meeting of the Panel to review the detailed plans for this evaluation and comment on its focus and scope.

This report responds to the evaluation plan and to the Panel's comments and suggestions.

2. Literature Review

When developing the evaluation plan and throughout this evaluation, we have conducted a review of the literature relating to next-generation biofuels. The purpose of this review is to provide an overall context for the role and activities of the NGBF. The review provides an assessment of:

- Developments in biofuels sector including government programs in other jurisdictions. This provides an international context for the NGBF.
- The economics and policy analysis literature on the impacts of biofuels.
- Recent developments in the market for biofuels and in related markets.

References appear throughout the report and are listed at the end.

B. OPERATING DATA AND INTERNAL NGBF DOCUMENTS

The evaluation examined the Fund's management information, including submissions to the Board of Directors providing information on individual projects and on the overall status of the Fund. We also reviewed project submissions, Indications of Interest introducing a potential project and the Applications for Funding including application documents, due diligence reports on the application and submissions to Board Committees and the Board of Directors.

The Fund has developed a number of reports and analyses including the business case, investment strategies, overviews of the biofuels sector and updates to these documents. These have been a valuable resource for this evaluation.

C. INTERVIEWS

As we began the study, we requested that the Fund provide a list of individuals who are knowledgeable about the Fund and its operations. We interviewed many of those identified and supplemented the list during the course of our interviews. Since the evaluation design calls for commentary on the operation of the Fund and suggestions for improvements, the views of those who have worked with the Fund are quite important. We interviewed representatives of projects that were in various stages of development: considering a plant in Canada; developing a project concept after submitting an Indication of Interest; developing an Application for Funding; after Application for Funding accepted, receiving support from NGBF and developing detailed project plans; and project cancelled, withdrawn, or inactive. Here is the count of interview respondents classified by their relationship to the Fund:

- STDC Senior management and Board 5
- Federal departments 8
- Proponents and senior member of project teams 14
- Representatives of groups, associations, associated with multiple projects 2
- Investment specialists 4
- Officials from similar programs 4

As we began each interview, we asked for permission to record the conversation and gave our assurance that the recording would be confidential, the recording and our notes would be protected and nothing would be attributed to an interviewee without their prior consent. All interviewees agreed to these arrangements. After we completed each interview, we reviewed the recording and summarized the discussion in working notes.

D. COST-BENEFIT ANALYSIS

As outlined in the project plan, we adapted the cost-benefit analysis developed for the SD Tech Fund for use with the biofuels projects. Projects are required to estimate CO2 emissions

and reductions compared to fossil fuels using the GHGenius model developed by Natural Resources Canada. We used those values and any estimates of emission reduction that were available for the projects in an analysis of the discounted present value of benefits to Canada from the operation of the first-of-kind plants supported by the Fund and follow-on production attributable to those plants.

E. LIMITATIONS

This evaluation is being conducted as scheduled, five years after the Funding Agreement was signed. The terms of reference for this work are set out in the Agreement, which directs us to provide a commentary on the administration of the Fund. This focus is quite appropriate at this early stage in the history of the Fund and we have carried out what is largely a formative evaluation. However we have commented on the prospects for the Fund to achieve its purposes.

IV RELEVANCE

This section of our report reviews the rationale for the NGBF and responds to evaluating issues dealing with the following:

- Continued need for the program.
- Alignment with government priorities.
- Alignment with federal roles and responsibilities.

A. BACKGROUND

1. International Context

The International Energy Agency (IEA) is an autonomous agency that focuses on promoting energy security amongst its member countries and providing authoritative research and analysis on ways to ensure reliable, affordable and clean energy. In 2011, it identified a 'pressing need to accelerate the development of advanced energy technologies in order to address the global challenges of clean energy, climate change and sustainable development' (International Energy Agency, 2011). In the context of an examination of policy direction for a plan stretching to 2050, it identified key actions in the next 20 years.

> Concentrated action by all stakeholders is critical to realizing the vision laid out in this roadmap. In order to stimulate investment on the scale required to realize the deployment of sustainable biofuels envisioned in this roadmap, governments must take the lead role in creating a favorable climate for industry investments. In particular, governments should:
>
> - Create a stable, long-term policy framework for biofuels to increase investor confidence and allow for the sustainable expansion of biofuel production.
> - Ensure sustained funding and support mechanisms at the level required to enable promising advanced biofuel technologies to reach commercial production within the next 10 years and to prove their ability to achieve cost and sustainability targets (International Energy Agency, 2011).

2. The Economics of the Rationale

The rationale for the NGBF is strongly supported in the economics literature. A full discussion of the economics of the NGBF is shown in Appendix A to this report. Briefly, Government's expectations of the NGBF include the funding of projects that establish first-of-kind demonstration–scale facilities for the production of next-generation renewable fuels. The literature makes it clear that NGBF investments in biofuel technology can make potentially important contributions to the Canadian economy and Canadian society. These contributions

have their basis in the standard economic framework for analyzing public support for research and development, which focuses on factors that lead to market failure.

To receive an NGBF contribution, a project must demonstrate that the contribution is necessary to ensure that the recipient proceeds within the scope, timing, or at a location necessary to ensure that significant broad benefits accrue to Canadians. In other words, the funding gap would halt the development of the technology unless the NGBF grant was provided. The evaluation plan calls for an examination of the evidence that each project is fully or partially incremental, based on data from interviews with those who are knowledgeable about the project. This evaluation provides the first evidence on the existence of the gap and the extent that it would have stopped the development of the technologies being supported by NGBF contribution.

At this early stage in the NGBF initiative, no projects have entered the marketplace so we cannot report on directly observed social benefits from SDTC grants. We do, however, provide estimates of the likely ranges for these impacts. This analysis is based on a modelling approach that uses parameters from our earlier work on the SD Tech Fund and on estimates from the literature on the impacts of related R&D initiatives. The *Evaluation Plan* calls for an examination of the reduction in GHGs and other emissions that can be attributed to the SDTC grants to projects. As described in the cost-benefit component of this report, we further develop this aspect of the evaluation plan by providing preliminary estimates of the social benefit of the potential impacts arising from each project based on this modelling approach.

3. Advanced Biofuels in the United States

The United States identified two strong reasons to develop its biofuels capability, energy independence and reduction of greenhouse gasses. These policy drivers and the availability of stimulus funds allowed the government to mount a significant array of supports for its biofuels industry, expanding the production capacity for grain ethanol and supporting the development of the first commercial-scale biorefineries. The Renewable Fuel Standard program and the first regulations (RFS1) were created in 2005 under the Energy Policy Act. Under the Energy Independence and Security Act (EISA) of 2007, the RFS program was expanded (RFS2) to create a demand for cellulosic ethanol as well as a system of tax credits to set a floor price for cellulosic ethanol of $3.00 per gallon if volume targets are not met (US Environmental Protection Agency, 2012) At the same time the Department of Agriculture announced $320 million in loan guarantees for advanced biofuel plants, $300 million in support payments for advanced biofuels, top-up of the ethanol tax incentive of $0.56/gallon and a $0.54/gallon import tariff was extended to 2010. A year later the Department of Agriculture announced a loan guarantee program that included $10 billion for innovative renewable energy projects including renewable fuels.

The Energy Policy Act called for the Department of Energy to conduct a competition to construct next-generation biorefineries and selected six projects. DOE awarded a total of $384 million to these projects with the objective of demonstrating profitable operation once their construction costs were covered. This would lead to replication of these first-of-kind plants.

It appears that in 2006 when the competition was being conducted, the US government shared the perception that next-generation biofuel technologies were ready for

commercialization. However, the proposals revealed that more development work was required. After selecting six proposals for commercial-scale biorefineries, in 2008 the Department supported more development work by announcing a $240 million program to support nine demonstration facilities built at 10% of commercial scale. Later that year it extended support further back in the development chain and in 2009 awarded $200 million to support additional pilot and demonstration facilities.

Today, the department lists five biorefineries that are receiving support for their development. We understand the first is scheduled to begin commissioning late this year.

4. Policy Development in Canada

i) Business Case for Development of Biofuels in Canada

The development of a new technology passes through a number of stages from fundamental research to market entry. When technologies move from the prototype stage to full demonstration, most are advanced by private research laboratories, individual entrepreneurs and small or medium sized enterprises. When the SDTC Foundation was established in 2002, it entered into an agreement with Canada that established the Sustainable Development Technology Fund (SD Tech Fund). The Fund was designed to address this gap as it existed for technologies that provide solutions for climate change and clean air problems.

An examination of the sectors addressed by the SD Tech Fund found that about 1/3 of the projects involved biomass including renewable fuels, co-products, bioenergy and enabling technologies. A part of its development work, in 2006 the Foundation published a study that examined the opportunities in this area "Renewable Fuel – Biofuels SD Business Case" (SDTC, 2006). This analysis focused on a vast development opportunity for Canada, establishing a biofuels industry based largely on Canada's forest resources. However, the report observed that the technologies that had been demonstrated by the Tech Fund to develop biofuels involve large capital expenditures. When these and other large capex technologies complete the demonstration phase that had been supported by the SD Tech Fund, they faced substantial scale-ups to a commercial scale of plant. Traditional sources of loan and equity financing have always been extremely reluctant to accept the risk inherent in supporting new technologies that have not operated at a commercial scale and require a large scale-up, a demonstration plant. The business case commented on 'market maturity' in these terms:

> Large institutional lenders are not yet inclined to support the next-generation biofuels industry because it is still not market-proven. This limits the availability of capital, and in those cases where capital is available, the projects are often heavily discounted to minimize financial risk. This tends to drive up the cost of money and reduce the financial attractiveness. This situation is expected to improve, however, as more successful projects come on line.

ii) Canada's Renewable Fuels Strategy

In 2006, Canada began to examine ways to reduce the consumption of fuels derived from finite non-renewable crude oil in favour of biofuels derived from renewable resources. This move was expected to reduce lifecycle emissions from fuel production, considering extraction/feedstock, production/refining, distribution and consumption. In other words, it should reduce the greenhouse gas (GHG) intensity of the fuels consumed in Canada. As well, reliance on biomass feedstocks should contribute social and rural development benefits.

The Canadian government generally supported the views outlined in the international literature. However, as described by one commentator, 'people generally thought that next-generation biofuels were about five years from commercialization and they have held that view for about 15 years.'

Government was aware of the shortcomings associated with first-generation renewable fuels, principally grain-based ethanol. While the production process had achieved significant efficiency improvements, growing feedstock requires substantial volumes of fuel and fertilizer and ethanol production consumes energy and releases significant volumes of GHGs. Since the feedstocks could be used as food, their use to produce fuel gave rise to a controversy, particularly as food prices increased. Blending ethanol with gasoline also introduced significant logistical challenges because ethanol is corrosive, is miscible with water, requires an atypical formulation of gasoline for blending and has lower specific energy than gasoline. Further, discussions with representatives of Agriculture Canada suggested that Canada's supply of grain feedstocks is limited compared to other countries and it appeared difficult for Canada to produce significantly more than the amount of first generation ethanol required to meet the initial regulation, a 5% blend with gasoline.

Next-generation biofuels promise to address many of these issues. The comparison is complex because a wide variety of feedstocks and conversion technologies could be used to produce about a dozen different fuels. In general, because they rely on non-food feedstocks, next-generation fuels avoid the food versus fuel controversy. Some potential next-generation fuels would avoid the logistical problems of ethanol and could be blended in higher concentrations with standard gasoline formulations. Projections of life-cycle GHG emissions indicate superior performance compared to first generation fuels. However, since none of the next-generation fuels are in commercial production, the GHG projections must rely on estimates and their accuracy remains a concern. Further, projections of other potentially important environmental impacts, including land use, habitat preservation, as well as soil and water impacts are typically at very preliminary stages and much work remains to be done.

Throughout the policy discussions, it was clear that development and use of first generation fuels was seen as an appropriate first step in the movement toward biofuels. But achieving the anticipated benefits requires that next-generation fuels be developed and used.

In light of the policy considerations sketched above and in line with positions taken in a number of other countries, Canada committed to a strategy to expand the Canadian production and use of renewable fuels. The strategy comprises four key elements:

- **Increase the retail availability of renewable fuels through regulation.** Federal regulation requires 5% renewable fuels content in gasoline and 2% in diesel and heating oil. The notice of intent to develop this regulation was published in the Canada Gazette (2006) and the regulations came into force in 2010 and 2011 respectively. The regulations do not differentiate between first and next-generation renewable fuels, as had been done in the United States.
- **Assist farmers to seize new opportunities in the renewable fuels sector.** The ecoAgriculture Biofuels Capital Initiative (ecoABC) provides $200 million in repayable contributions for construction or expansion of transportation biofuels facilities. The program was extended by two years to allow time for construction to be completed and closed September 30, 2012. The Biofuels Opportunities for Producers Initiative (BOPI), a $10 million program, subsequently increased to $20 million supports development of business proposals or other studies to expand biofuels production capacity. BOPI is now closed.
- **Accelerate the commercialization of new technologies**. The $500 million NextGen Biofuels Fund™ is aimed at supporting the establishment of first-of-kind commercial scale demonstration facilities for the production of next-generation renewable fuels and co-products. The fund will help Canada sustainably meet its Renewable Fuels Standards. The purpose of the fund is to encourage retention and growth of technology expertise and innovation capacity for next-generation biofuels production in Canada. The Fund must complete its disbursements by March 2017.
- **Support the expansion of Canadian production of renewable fuels.** To stimulate domestic biofuels production, Natural Resources Canada established ecoEnergy for Biofuels (ecoEBF) to provide up to $1.5 billion of operating incentives to biofuel plants in the period from fiscal year 2008-09 to 2016-17. Admission to the program is closed.

The NextGen Biofuels Fund™ is one of the 'four pillars' of Canada's renewable fuels strategy. The three initiatives supporting the first generation fuels are in place and have generally achieved their objectives. Canada now has sufficient capacity to produce about 90% of the volume targets for ethanol that were established for the ecoEBF and production will be supported by operating incentives until 2017. Current projections indicate the production of biodiesel has fallen well short of target and at least in the intermediate term, it appears that it will remain so (Natural Resources Canada, 2012).

iii) Provincial Initiatives

A number of provinces have established a requirement for blended fuels. From British Colombia to Quebec, provincial regulations call for ethanol to be blended with gasoline, most at 5% but 7.5% in Saskatchewan and 8.5% in Manitoba. Biodiesel regulations are established from British Colombia to Manitoba, with BC at 4% and the others at 2%.

British Colombia's has included in its regulation a non-compliance charge, an incentive to encourage low carbon fuels. A recent analysis indicates that this could amount to $0.14 per litre subsidy for next-generation ethanol (SDTC, 2012).

Alberta has established the Bioenergy Producer Credit Program (BPCP) that will apply to bioenergy production from April 2011 to March 2016. The program provides an incentive payment ranging from $0.06 to $0.14 per litre depending on the fuel, next-generation fuels receiving a higher subsidy, and the plant size.

Saskatchewan has implemented a production incentive of $0.15 per litre for ethanol produced and consumed in the province. In 2011 established a production credit for biodiesel produced in the province. The biodiesel credit of $0.13 per litre will expired in 2016.

In 2008, Manitoba established a production incentive of $0.20 for ethanol that will fall to $0.15, then to $0.10 and will terminate in 2015. The province provides an incentive of $0.14 per litre of biodiesel that will end in March 2015.

Ontario has implemented the Ontario Ethanol Growth Fund (OEGF) in 2005. The program offers capital incentives for new ethanol production facilities and production grants that will run until 2017. Participation in the program is now closed.

Quebec offers a refundable tax credit program for cellulosic ethanol production which could reach $0.15 per litre. The program will operate until March 2018.

5. The NextGen Biofuels Fund™

i) Requirements of the Funding Agreement

The Funding Agreement recognizes the need to move beyond first-generation production pathways if Canada is to sustainably meet possible future expansions of its Renewable Fuels regulation beyond the current level of 5% renewable content in the gasoline pool and 2% renewable content in the diesel/heating oil pool. It also recognizes the difficulties faced by renewable fuel technology developers in accessing sufficient private sector capital to demonstrate the technological and economic feasibility of production pathways to produce next-generation renewable fuels at large demonstration-scale (SDTC, 2007).

The Funding Agreement incorporates a number of requirements that reflect the policy context, the renewable fuels strategy and the NGBF's role within that overall strategy. The purpose of the NGBF, as specified in the Funding Agreement, focuses on developing next-generation biofuel facilities in Canada that yield improved benefits to Canada, as compared to traditional (first-generation) biofuels:

> "(a) facilitate the establishment of First-of-Kind Large Demonstration-scale facilities for the production of Next-generation Renewable Fuels and Co-products;

(b) improve the Sustainable Development Impacts arising from the production and use of Renewable Fuels in Canada; and
(c) encourage retention and growth of technology expertise and innovation capacity for the production of Next-generation Renewable Fuels in Canada" (SDTC, 2007).

The Funding Agreement defines sustainable development impacts in the specification of the contents of project applications. The definition focuses primarily on life-cycle energy balances and includes general environmental impacts, both compared to first-generation renewable fuels.

The Funding Agreement provides a total of $500 million but that amount will be transferred to the NGBF over a number of years. The initial amount of $200 million is followed by amounts up to specified limits per fiscal year, $25 million in fiscal years 2008-2009 and 2009-2010 and $50 million in each of the next five fiscal years. (Articles 4.01-4.03). The agreement allows these amounts to be re-profiled. (Article 5.03 (c)).

The Funding Agreement (Article 8.03(a)) limits the total amount available for a single project to the lesser of 40% of eligible costs or $200 million. Given the anticipated scale and cost of the next-generation biofuels plants, it appears that the NGBF will have sufficient funds to support only a relatively small number of plants. For example, one might anticipate that a single project could request the maximum amount, $200 million, or 40% of the total fund, for its plant. On this basis, it is clear that the NGBF presents a very different management challenge than the SD Tech Fund. In particular, it appears that the diversity of the NGBF portfolio may be severely limited compared to the SD Tech Fund, which to date has approved 228 projects, and accordingly the risk associated with the NGBF achieving favourable results will be higher.

In summary, the NGBF is directed to solicit proposals for next-generation biofuels and to support the most promising applications. The selection criteria specified in the Funding Agreement indicate that in the longer term, the projects should have the potential to provide positive environmental benefits and to establish economically viable production facilities in Canada. However, the individual projects are expected to be large and the NGBF will be able to support only a relatively small number of projects, which increases the risk that the NGBF may not yield net positive benefits to Canada.

ii) Program Logic Model for the NGBF

The Evaluation Framework report presented a logic model that had been developed for the NGBF. That model guided the development of the framework and the planning study for this First Interim Evaluation. The most recent Corporate Plan offered a redrafted version of the model. The linkages represented in the model are unchanged. A copy of that model is shown in Appendix A to this report.

B. ALIGNMENT WITH PRIORITIES AND WITH FEDERAL ROLE AND RESPONSIBILITIES

The Fund is an integral component in Canada's Renewable Fuels Strategy which sets out Canada's approach and operational programs. The programs that constitute three of the four legs of the strategy are in place and generally have achieved expected outputs, establishing production capacity operational supports for existing first-generation fuels and regulatory support for blending biofuels. The Funding Agreement allows the Fund to exercise its judgment in selecting projects to support and specifies that the available funds should be disbursed by March 2017. Overall, the Strategy remains the policy of government and the activities supporting the strategy are in place and functioning in accordance with its general intent.

While some provincial governments are involved in providing supports for demonstration projects in their jurisdiction, as outlined above, those are clearly supplementary to the NGBF. There is no unnecessary overlap or duplication of financial supports for the establishment of next-generation biofuel facilities.

C. CONTINUING NEED FOR THE FUND

1. Availability of Funding for Canadian Biofuels

The interviews conducted for this evaluation explored the availability of funding for first-of-kind biofuel plants. We discussed the rationale for the Fund at the time of its inception, the changes in the economy and financial markets since that time and any other factors that may affect the validity of the rationale in 2012.

Interview respondents who are familiar with the situation in Canada were unanimous that first-of-kind next-generation biofuel plants would be built in Canada only if government provided assistance in the scale available from the Fund. Their language was unequivocal:

- 'Absolutely essential'
- 'Without it, we would not be exploring a plant in Canada'
- 'Without support from the Fund, the project would be a non-starter'
- 'Essential to the project'
- 'Without the Fund, nothing would have happened'
- 'NGBF is critical to our business model in Canada'
- 'Having NGBF bumps Canada up in front of every other nation'

All interviewees described the risks inherent in a first-of-kind plant, including risk associated with the technology, feedstock, off-take, business model, stability of government regulation, stability of government support (political risk), and for debt holders, the lack of performance guarantee for brownfield facilities. Traditional sources of equity and debt funding

are unwilling to accept such risks. Both project proponents and financial specialists stressed that investors want clear evidence that such risks have been eliminated. Before they will consider supporting a next-generation facility, as a minimum they want to see results from an operating commercial-scale plant that can be used to accurately predict the performance of their investment. Some believe that this level of confidence will require more than a first-of-kind plant because that the first plant is unlikely to show a satisfactory return on investment.

2. Does the Need Still Exist?

Again, respondents were unanimous. The need clearly existed when the Fund was established. The need is more sharply defined in the current economic and financial conditions. Equity and debt are much more conservative today than they were five years ago. If government wants to encourage development of Canada's biofuel potential, the Fund represents the minimum level of support required for emerging Canadian technologies to build first-of-kind plants and for non-Canadian companies to consider developing a first-of-kind plant in this country. Some of those interviewed are actively considering potential new plants in locations of interest around the world. All the locations under consideration offer supports at least equivalent to that available from the Fund.

The external environment has become less receptive to new biofuels projects. The funding for capital support that has been available from the Department of Energy in the United States has come to an end as has one of the two loan guarantee programs of the Department of Agriculture. DOE will continue to support pilot and demonstration projects and plans to remain active with program supports such purchases by gasoline and diesel by the Department of Defense. As a result, the Fund may see more interest from potential projects that formerly would not have considered projects outside the United States.

D. CONCLUSION: THE RATIONALE FOR THE NGBF IS STRONGLY SUPPORTED

All of the lines of investigation that examined the rationale for the NGBF found strong support for the need for the Fund and for its continued existence. The Fund is aligned with the current priorities of the Government of Canada. The funding gap continues to exist and the evidence indicates the Fund does not displace private sector funding for projects. Government's principal policy documents indicate that the Fund's objectives remain aligned with the current priorities of the Government of Canada. The need for the Fund is unquestioned among all key informants and they voiced strong support for the role it is playing in the development of next-generation biofuels in Canada.

V PERFORMANCE OF THE FUND

A. INITIAL STRUCTURE AND ADMINISTRATION OF THE FUND

The NGBF Funding Agreement gave SDTC considerable scope in the organization and general approach it could take to discharge its mandate. The decisions taken by management and the Board of Directors have shaped its approach and account in large extent for the rate of progress and the current financial condition of the Fund. In our view there are three critical components. The following sections outline each.

1. Staged Approach to Project Management and Commitment of Funds

i) Development of the NGBF Stage Gate Process

The Funding Agreement was signed in September 2007 and at that time the Fund was engaged in discussions with its first potential project. The company had already arranged a grant with the Department of Energy and the project involved significant partners, including Shell. Looking back, it appears there was a general expectation that the Fund would promptly approve the project and it would proceed.

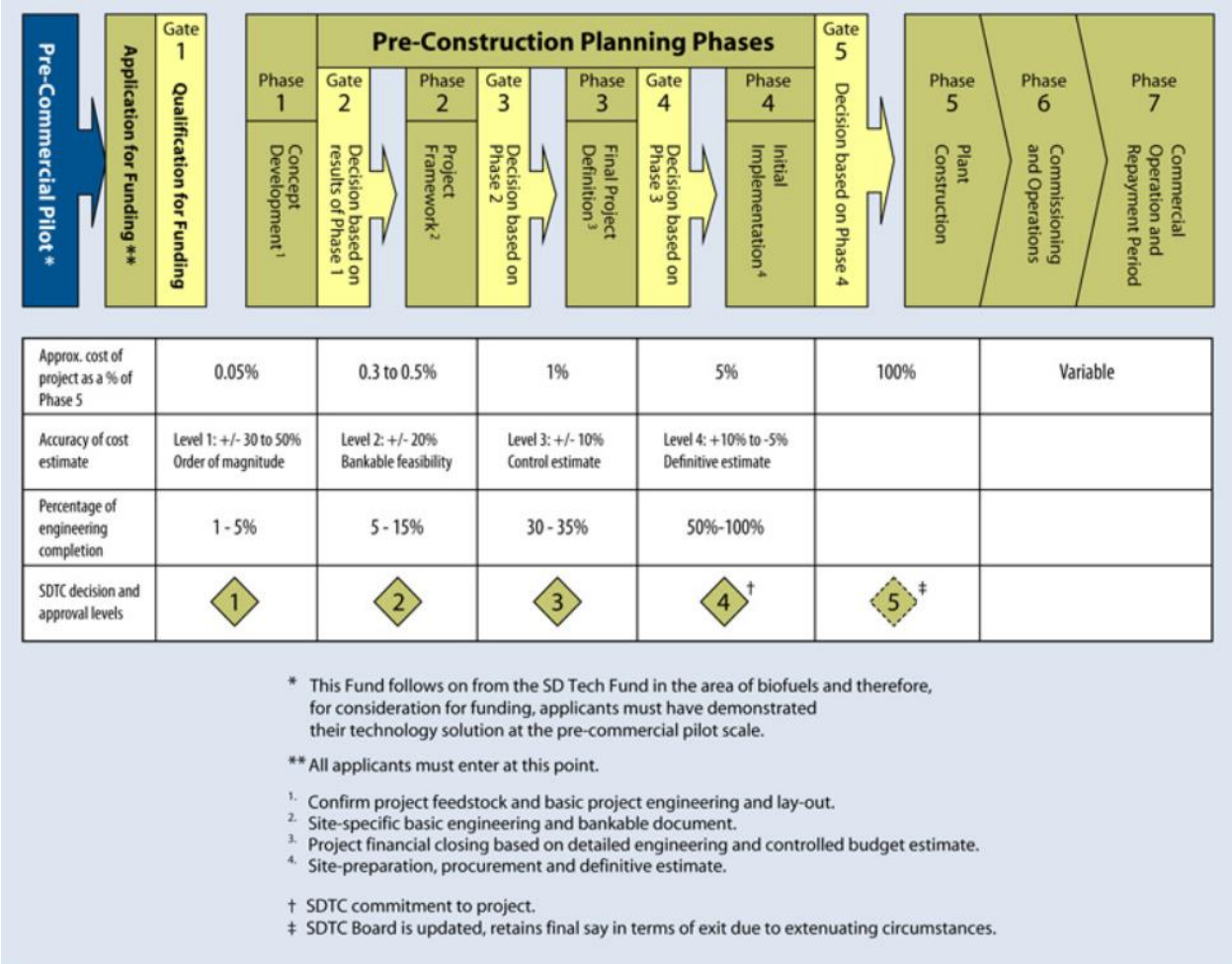
As it was being established, the Fund decided that it would employ the project management system described as the 'Stage Gate' approach. Our review of this approach shows that it is the 'industry standard' for management of complex projects such those supported by the NGBF. Most of the proponents that are currently working with the Fund use this approach in projects of this type. From the Board's point of view, two additional factors supported the choice:

- **Low diversification of Fund's investment portfolio, with consequent high risk**. The Fund was well aware that its resources were very limited when considered against the scale and number of potential projects. So the consequences of a bad investment, in the extreme case a derelict plant, would be severe. For example, the initial estimate of the capital requirements for the first project was at a level that the Fund could invest the maximum allowable under the Funding Agreement, $200 million, which is 40% of the Fund's total resources. SDTC's experience had amply confirmed that developing new technologies is a risky business, bringing to mind the maxim of venture capitalists to diversify their portfolio 'make many small bets rather than a few large ones.' Clearly this option was not available to the Fund. Since it could only invest in a small number of projects, it should make every effort to minimize the risks and challenges faced by each project. The stage gate approach is designed to achieve that result.
- **Stewardship of Public Funds**. The Funding Agreement calls for the Board to 'exercise its discretion in the allocation of funding to eligible recipients'. The Board discharges this responsibility with full knowledge that it must also exercise stewardship of public funds. Examining potential investments carefully at each stage of a project's

development and withholding the full commitment of funds until they are required to begin construction supports the Board's effort to discharge this responsibility.

The SDTC web site provides a detailed description of the process which the Fund calls the Project Assurance Process (PAP). In broad terms, the PAP moves the project from a very general concept to a completely designed and 'de-risked' project that is ready to build. The PAP identifies the many key elements in a project plan and it sets out the status of each element at each phase of development, Exhibit V-1, which appears on the SDTC web site, illustrates the development of the cost estimates for the project as the planning progresses from the Application for Funding (AFF) through Phase 1 to Phase 4 when the decision is taken to grant full release of funds for construction.

Exhibit V-1 Project Assurance Process Showing Accuracy of Cost Estimates



Source: SDTC Web Site

The evolution of the cost estimates shown in the exhibit is mirrored for every aspect of the project. The PAP requires that all aspects advance in parallel so that at each decision gate, the team can review all aspects of the project to identify any issues may have emerged. They have an opportunity to make appropriate adjustments to accommodate those issues or at least

minimize their impact before they become frozen in the design as the project proceeds through the next phase. This review provides the basis for a decision whether to proceed to the next phase. If all partners in the project agree to proceed, the Fund agrees to support its share of the costs of the next phase. The decision at the end of Phase 3 allows the first stages of construction to begin and at the end of Phase 4 the Final Investment Decision is addressed, which authorizes construction to proceed.

The Fund requires that a stage gate approach be used. However it is flexible on the details of the implementation. Where a proponent has experience with this approach, the Fund has agreed with the proponent to use the company's version of the process, provided that it accommodates the basic requirements of the Fund, particularly completion of the demonstration and accommodation of the environmental considerations set out in the Funding Agreement. If the proponent's team has no experience with a stage gate process, the Fund requires that its interpretation of the process be used.

While to the uninitiated it can appear tedious, time consuming and expensive, the process guides project developers to complete all the essential steps in an ordered sequence. At each stage it critically examines the project plans at each step to confirm that the plans will lead to a successful project. If the reviews identify potential problems, risks to the project or weaknesses in the plans, the project has an opportunity to introduce changes before those problems become embedded in the design. With the changes incorporated in the project plans, the team can reassesses the viability of the project.

ii) Evaluation Findings: Use of Stage Gate Supported by Experience and by Demonstrated Improved Project Performance

Our interviews confirmed that the use of the stage gate system comes as no surprise to organizations or people who have experience with large complex capital projects. In large multi-nationals such as the major petrochemical companies, the use of this approach is mandatory.

However an alternate view emerged during the interviews. If a team has limited experience with the stage gate approach, the process may appear unduly complex and a first experience with it can be daunting. The appropriate level of detail or documentation may not be obvious and lead to excessive effort or re-working to meet the expectations of reviewers. Although we have no direct evidence, one interviewee mentioned that some potential projects may not have been introduced to the Fund because of the perceived burden and delays imposed by the NGBF approach to project planning.

A more traditional approach to public sector support for smaller, less complex capital projects assumes that the judgment of private sector partners can be relied on to justify public investments. If the private sector is willing to support a project, the decision to proceed provides sufficient assurance of the quality of the project that public support can reasonably be granted. On this basis, some programs conduct brief reviews of documents before funding projects. Programs that proceed more slowly and carefully may complete a 'due diligence' review of detailed proposals to select successful applicants to the program. The most rigorous procedure requires a site visit as part of the DD procedure. This process is roughly equivalent to Stage 1 of the PAP process, the due diligence review of the AFF. This general approach is followed by the

SDTC's SD Tech Fund and two Natural Resources Canada programs that contribute to Canada's Renewable Fuel Strategy. The Ethanol Expansion Program invested just under $100 million in nine facilities, new plants or expansions of existing facilities. The department's Investment in Forest Industry Transformation (IFIT) program is investing $100 million (a maximum of $10 million per project) and operates under significant time pressure. It receives annual appropriations and any unspent money may be lapsed at the end of the fiscal year. Under these conditions the program pushes for rapid response and places much less emphasis on due diligence reviews of proposals. All three programs deal with smaller investments where the stage gate approach with detailed controls, continual examination of project plans and assessment of risks may not be justified. However our discussions with these and other programs found general agreement that as project size increases, the related complexities increase as well and for large and complex projects, the complexity and risk justifies the more rigorous approach such as stage gate.

Our research confirmed that the US Department of Energy follows the stage gate approach when working with the biorefinery projects that it supports. The approach was highlighted in a recent release on the Department's 'Bulletin Board of Lessons Learned' (US Department of Energy, 2012), and the details of its approach will be discussed in a paper scheduled to be presented the forthcoming AIChE conference (*Substantial Involvement by DOE to Address Scale-up Challenges for Biorefineries*, Forthcoming).

With first-of-kind technologies, it is not unusual that a project will identify problems that cannot be accommodated in the current project, leading proponents to abandon the project during the stage gate process. While this may be disappointing, it is clearly in the best interests of all involved with the project. Certainly this is preferable to building a plant that never works satisfactorily and is abandoned, sacrificing capital investment and in no small measure, the reputation of the technology, the proponents, the entire biofuels sector and the public programs that supported the project. When a project is withdrawn during the stage gate process, the proponents have an opportunity to regroup, respond to the problem perhaps with more research, or a modification to the concept. The technology then has an opportunity to be re-launched in a revised and stronger project.

Experience has demonstrated the benefits the stage gate process brings to complex projects. For example, consider the results reported by Independent Project Analysis, Inc. (IPA), a consulting organization that serves clients around the world, evaluating major projects. Each year it assesses many hundreds of projects including in the order of 50 that implement new technologies. IPA has assembled a database of its results, including over 1,000 new technology projects ranging in size from $0.5 million to $2 billion in many sectors including refining, specialty chemicals and pharmaceuticals. An analysis of the results for projects involving new technologies led to a number of conclusions that were summarized in a presentation to the Biomass 2010 conference. Here are the highlights:

- Despite the importance of new technology, most companies today lack a coherent approach. They have no rules or guideline on how to commercialize new technology and would like to have 'A+ capability' with 'D- resources'.
- Start-up companies are often pushed by inexperienced investors to perform faster than humanly possible.

- Over 40% of moderate and high innovation efforts were outright failures. Fewer than 20% delivered all that was promised at full-funds authorization. Success and failure do not necessarily reflect the technology, but often indicate process development and project practices.
- First-of-kind processes have higher cost growth than those that have been developed at demonstration-scale (average cost growth 0% for projects following demonstrations compared to 25% for First-of-Kind (no demonstration)).
- New technology projects fail because risks – business and technical – are underestimated or not recognized. Some project cultures seek to downplay all project risks for fear of turndown at authorization. Many project systems do not see enough innovative projects to develop the appropriate respect for them.
- Development work in pilot plants and completion of R&D before project authorization substantially improve results. Operability (rate of production), averages 70% where pilot plant has been operated and 30% with no pilot. Operability is 80% if R&D is complete at project authorization and 50% if authorization goes ahead without R&D closure. Start-up time with a pilot plant is half compared to time if there was no pilot plant.
- Use of Best Practices allows a new technology project to use contingencies that would apply to a standard technology project. With underdeveloped project management processes, new technology projects require contingency set at 66% of base estimate (EERE, 2012).

Thus the IPA analysis supports the approach taken by the Fund, which requires that the AFF reflect findings from a demonstration plant and that the project use the stage gate approach to project planning.

iii) Conclusions on Project Management

In our view, the record of the stage gate approach clearly justifies its use by the NGBF. Ultimately the judgment on the best approach to managing large capital projects that may involve new technologies will draw upon the record of success or failure of the funded projects. Metrics such as those reported by IPA will indicate the extent that the risk mitigation of the stage gate process is successful in improving the overall performance of the important projects. At this stage, the weight of evidence strongly supports the Fund's use of the stage gate approach.

2. Investment Strategy

i) Develop a Business Case

Early in its development, the Fund developed a business case. The stated objective of this exercise was to:

Articulate a pro-active and targeted NGBF investment strategy, aiming at the most promising candidates selected on the basis of comprehensive benchmarking parameters, all with a view to implementing the NGBF mandate.

The result was available in 2007, was a wide-ranging document that scanned the biofuels sector, describing its complexity, with multiple feedstocks, multiple technology platforms, and multiple markets (SDTC, 2007). The business case suggested a method of identifying candidates for the fund, applying a number of filters to the generic biofuels pathways to highlight approaches that satisfy the NGBF criteria. It recommended the use of the theoretical models of each of the biofuel production pathways that had been developed by the US Department of Energy's National Renewable Energy Laboratory and the GHGenius model developed by Natural Resources Canada. The business case applied these tools to benchmark the pathways. This work provided initial guidance to the Fund and it provided a template for benchmarking specific project designs that would be developed and submitted to the Fund for support.

The business case highlighted Canada's vast supply of feedstocks for next-generation fuels. For example, employing just wood waste, agricultural residue, municipal solid waste and manure, Canada could support the equivalent of 120 world class biorefineries capable of producing 25 times the Canadian RFS increment to 2034.

The business case recommended that a company has operated a pilot or demonstration facility in a commercial setting. Emphasizing that the facility should support the design of a commercial scale plant, it suggested that a demonstration plant should process a minimum of 25 tonnes per day of feedstock and should have logged at least 2000 hours of continuous operation in order to have the experience necessary to efficiently engineer and construct a commercial facility.

The approaches outlined in the Business Case have guided the Fund in its development and most of its recommendations are incorporated in the Fund's procedures.

ii) Selection Criteria and Decision Process

The criteria that qualify projects for funding are set out in the Funding Agreement. The Fund is responsible for requesting project proposals, assessing the proposals received and funding those projects "which, in the opinion of the Board, have greatest merit." The Fund faced the task of interpreting the various directions given in the Funding Agreement in light of the realities of the market and the development challenges faced by individual projects. The definitions in the agreement were broadly drawn:

- "Biomass" means any type of organic material that is available on a renewable or recurring basis. Biomass is the primary input into Production Pathways for the production of Renewable Fuels.
- "Feedstock" means the Biomass input material used to produce Renewable Fuels.
- "First-of-Kind" means that a facility producing Next-generation Renewable Fuels is using a Production Pathway that has not been demonstrated before at Large Demonstration-scale.

- "Free Cash Flow" means EBITDA (earnings before interest, taxes, depreciation and amortization), as defined by GAAP, minus: (i) current income and capital taxes; (ii) interest charges on debt; (iii) principal repayment on debt; and, (iv) routine capital expenditures (i.e. expenditures incurred to maintain production).
- "Large Demonstration-scale" means the minimum scale required to de-risk the Production Pathway for commercial replication. Large Demonstration-scale facilities are no smaller or larger than what is required to prove the technical feasibility of the Pathway at a profitable commercial scale. The scale is such that, if successfully demonstrated at Large Demonstration-scale, subsequent projects at any scale will not require government intervention to address technology risk.
- "Renewable Fuels" means any alternative to gasoline, diesel or heating oil that is derived from Biomass.
- Eligible projects must exhibit these characteristics:

    a) be a First-of Kind facility that primarily produces a Next-generation Renewable Fuel at Large Demonstration-scale;

    b) be located in Canada; and

    c) use Feedstocks that are or could be representative of Canadian Biomass.

The NGBF should exercise its discretion in selecting successful applicants in accordance with these criteria:

> (a) the Eligible Recipient's access to the necessary technical, financial and management capacity to successfully undertake the Eligible Project;
> (b) the level of necessary funding required from the Foundation to ensure that the Eligible Project proceeds;
> (c) the potential of the Production Pathway to deliver Sustainable Development benefits (social, economic and environmental) by:
>
> (i) sustainably expanding Renewable Fuel Production in Canada;
> (ii) improving the environmental benefits arising from the production and use of Renewable Fuels including the Life-cycle fossil energy balance and life-cycle emissions of Greenhouse Gases;
> (iii) reducing the overall financial costs of Renewable Fuels; and,
> (iv) generating economic benefits for a wide range of communities.

The agreement sets out the contents of applications which includes an assessment of sustainable development results, described as:

> Sustainable Development Results, meaning the estimated Sustainable Development Impacts that the proposed Production Pathways promise to deliver to Canada. The application must demonstrate that the proposed Production Pathway has the potential for:
>
> (i) A net positive life-cycle energy balance;
> (ii) Improved life-cycle fossil energy balance compared to that associated with traditional renewable alternatives to gasoline;

(iii) Reduced life-cycle emissions of greenhouse gases compared to those associated with traditional renewable alternatives to gasoline;
(iv) Other positive environmental impacts compared to first-generation renewable fuels production pathways; and,
(v) Socio-economic benefits accruing to Canada.

In summary, feedstocks are defined broadly, including but not limited to lignocellulosic materials. Projects should be large enough to eliminate scale-up risk for an optimal size of commercial plant. It should be noted that these conditions post two significant challenges to the proposals being considered by the Fund:

- **Financial performance.** NGBF projects must show acceptable financial performance without any subsidy or support beyond the contribution from the Fund. This is a more stringent test than was faced by proposals for first-generation plants. These plants can count on the production subsidy provided by ecoEBF and fuel standards that established a secure market for their output, neither of which is available the NGBF projects. Admission to the ecoEBF is now closed and the EEP and ecoABC programs have increased Canada's capacity to produce ethanol to a level approaching that required by the fuel standard. It is also significantly more challenging than the conditions facing first-of-kind biorefinery projects in the United States. These US projects have relied on a number of supports beyond the grants from the DOE including loan guarantees from DOE and from the Department of Agriculture, production subsidies, tax incentives, fuel standards that establish specific requirements for next-generation fuels, large defence department purchasing programs for biofuels and Renewable Identification Number credits that are payable by obligated parties.
- **Challenging, and moving, targets.** Proposals to the Fund must have the potential to demonstrate that they can achieve better emission reduction and lower cost than first-generation fuels. Of course this is a moving standard. First-generation plants are operating around the world and are learning from that experience and improving their financial and environmental results. However this uncertainty represents the conditions that the new technologies will face in the future when investors and policy analysts consider the results from the first-of-kind plant against the alternative investment opportunities that will be available at that time.

Interestingly, the Funding Agreement does not specify a standard of financial performance for the first-of-kind plant. However, if the plant is to demonstrate a pathway, it must at least provide sufficient information to support the design of a second plant. This implies that the plant should as a minimum show positive cash flow so the plant can continue operations without additional sustaining funds.

iii) Identify Potential Candidates for NGBF

As the Fund was launched, it had one clear candidate for funding and a mandate to support first-of-kind plants across a wide range of technologies and pathways. The Fund needed to understand the biofuels community, the organizations that were working in the field that could develop potential projects for NGBF support. The Fund developed this resource through a

sequence of steps that was first described in the Business Plan. The following description provides most recent results:

- **Next-Generation Biofuel Landscape.** A number of sources contributed to a comprehensive list of all the organizations in the sector. After eliminating academic and research organizations as well as those focused solely on first-generation fuels. This produced a global list of potential candidates for the Fund, about 180 companies.
- **Potential Candidates.** A further examination identified those that did not conform to the specifications set by the Funding Agreement in terms of non-food feedstocks, next-generation pathway and either a pilot or demonstration development stage. The Fund assessed the state of development of each candidate and retained only those that had at least begun developing a pilot or preferably a demonstration site to develop and test the technology. The result was a list of ninety-five leading biofuel technology companies that were compliant with NGBF requirements.
- **Project-Ready Candidates and Benchmarking.** Finally the Fund assessed project readiness. Potential candidates were benchmarked on the measures identified by the business case using the NREL models. Had the candidate completed an integrated continuous demonstration with reasonable scale-up risk? Was it ready to enter front-end development but before the last phase of front-end development? A final list of 24 potential candidates emerged as 'project-ready'.
- **Benchmarking and Applications for Funding.** Projects invited to submit an AFF are benchmarked on measures addressing technology pathway and project parameters. This procedure validates and ranks AFF projects. Six to ten companies qualify.

This procedure identified a list of candidates that satisfied the Board's expectations and led to an investment plan. About one-third involved Canadian proponents. All of the principal pathways feedstocks, except algae, were represented by at least one potential project.

iv) Benchmarking the Candidate Projects

Using the NREL models and the measures recommended by the NGBF Business Case, the Fund examined the characteristics of the technologies represented in the 24 candidates. All showed sufficient promise that they should be considered for support by the NGBF. While some characteristics are not ideal, the analysis did not find a basis that would justify discontinuing development of a particular pathway. For example, the Fischer Tropsh pathways show high capital cost per liter of gasoline equivalent, currently higher than target. However, this pathway offers some attractive features, particularly the potential to produce drop-in fuels which have a number of advantages over products that require blending with fossil fuels and the capability to produce value-added co-products.

v) Evaluation Findings on the Investment Strategy

(a) Emphasis on Selected Pathways?

Some interview respondents have suggested that the Fund should restrict its focus to specific pathways or to more stringent selection criteria, for example a funded first-of-kind

project should be able to reasonably project capital expenditure of less than $1.00 per liter of output for follow-on projects. The Fund has chosen to cast a wider net. Its minimum requirement is a positive cash flow from the first-of-kind plant. In principle, this approach considers any technology that satisfies the Fund's selection criteria, as established in the Funding Agreement. Beyond that, it recognizes that each of the technologies have substantial potential to evolve from the first-of-kind plant, showing technology improvements and economies of scale that are difficult to predict while the first-of-kind plant is still on the drawing board. The Fund prefers to rely on a process of natural selection. The performance achieved by a pathway in the longer term, in the 'n^{th} plant' will identify the winners.

Our review indicates that this approach has merit. The 'learning curve' of improvements that emerge with time and experience can have major impact on productivity and cost. For example, a study of the cost of producing corn ethanol indicates that the standardized cost of production were reduced by 45% from 1983 to 2005, falling by about 13% for every doubling in cumulative production (Energy Policy 37, 2009). Improvements of this magnitude indicate that it is simply too early to pick winners. On this basis, the Fund should strive to facilitate projects from a variety of pathways, gaining insights and building Canadian competence in each pathway.

Exhibit V-2 shows the current position. The exhibit displays the pathways identified for the 24 project-ready projects discussed above. Then we show pathways for the active projects, those that working toward initial approval for funding or advancing in the PAP. The final column shows the pathways for those projects that have submitted an Indication of Interest and were invited to submit an Application for Funding.

Exhibit V-2 Project-Ready Candidates by Pathway and Project Status

Principal Biofuel Technology Pathways	Project Status		
	Project-Ready	Funding Approval or PAP	In Discussions, pre AFF
Biochemical	14	2	1
Thermochemical	4	2	
Pyrolysis	3	1	1
Algae			
Hybrid and Innovative	3		1

Clearly, the active projects and those that have been invited to submit an AFF represent the active pathways and therefore satisfy the Fund's investment strategy. We judge that this position responds to the expectations set out in the Funding Agreement to request project proposals throughout Canada, to assess them and fund those that in the opinion of the Board, have greatest merit (Section 2.03). As well, the strategy of maintaining contact with all proponents judged to be project-ready and inviting an AFF as soon as the proponent satisfies the eligibility criteria is in effect a continuous call for proposals. The process satisfies Section 8.01 of the Funding Agreement, to manage the application process in a clear, transparent and accessible manner to ensure that a wide range of potential recipients have the opportunity to submit proposals for consideration. The results shown in Exhibit V-2 and the findings reported above demonstrate that Fund has met these expectations.

(b) Scale of Projects

Some interview respondents who were not directly involved with a specific project were concerned about the scale of projects:

- 'Would prefer to see a cap on project size, say $100 million or at least a strong preference for smaller projects.'
- One respondent suggested the Fund's expectations were shifting 'The Fund is increasingly interested in co-products that could improve the overall project returns but increase capex and complexity.'
- 'The Fund may feel pressure that each project should be a good investment for Canada, therefore focusing on short term results from the NGBF plant. If so, that is setting the bar too high. The central issue is de-risking the core technology, not demonstrating low cost production or added niche products that improve the returns for the project.'

In this view, it is preferable to build a smaller simpler plant, foregoing returns to scale and accepting degraded economics for the first-of-kind project. The plant should focus on demonstrating the technology at commercial scale. Then, if the results justify it, the proponent can build at a larger scale or perhaps add additional components to the first-of-kind plant to produce co-products. That can be done later.

Our research did not encounter this view among proponents of projects. They described the Fund as focused on developing the best, most risk-free project. However, the concern does speak to the potential benefits of a restrained design and a general expectation of minimum returns from the first-of-kind projects.

vi) Conclusions on Investment Strategy

Our review indicates that the processes developed by the Fund reflect the directions of the Funding Agreement. The strategy has identified a large number of candidate projects spanning the range of biofuel pathways. Each project that is involved with the Fund has an opportunity to develop a project that satisfies the proponent's expectations, within the boundaries established by the Funding Agreement.

B. OPERATION OF THE FUND

1. Outreach and Awareness of the Fund in the Biofuels Community

i) Outreach

To be effective in its role of facilitating first-of-kind biofuel plants in Canada, the Fund must be well known in the biofuels community. The Fund invested considerable time and effort to be visible in the community and to raise its awareness of the Fund. To fulfill its role, the Fund

must be conversant with the views of industry leaders and the opportunities, challenges and recent developments of the biofuels industry.

Each year there are a number of conferences that are attended by representatives of most of these project sponsors, especially those that are actively moving toward commercialization. Members of SDTC staff regularly attend the major conferences in North America and they have made presentations on a number of occasions.

SDTC's SD Tech Fund has been a source of contacts since it has worked with many of the Canadian biofuels proponents at the small demonstration phase of their technology development. Some have completed their project and moved on to work with NGBF to develop their first-of-kind commercial scale plant and some are currently completing their demonstration project with the SD Tech Fund. Our interviews indicate that members of staff from the two funds are cooperating on current Tech Fund projects. To facilitate a potential transition to NGBF when the demonstration project is complete, staff are reviewing project plans to verify that the milestone achievements set out for Tech Fund projects respond to the expectations of the NGBF.

ii) Awareness of the Fund

Our interviews confirmed that NGBF is well known in the biofuels community. As one of the few government-sponsored sources capital support for commercial-scale projects, proponents are well aware of the Fund. In the words of interviewees:

- 'There is a basket of money hanging there. If (proponents) don't know about it, they don't know what they are doing.'
- 'I have known about NGBF for some time. One aspect of my responsibility is to keep up to date with the regulatory environment and sources of support available at the federal and local levels in all the countries of interest to my company.'
- 'When we talked with projects led by large corporations, some were unaware of the NGBF and grant money available in Canada. As they became aware of Fund, they are now starting to look at Canada.'

One proponent commented that his US firm first learned about the Fund from a board member who had discussions with a representative from Canada's Department of Foreign Affairs and International Trade. A person with multiple contacts with the sector commented that when proponents express interest in Canada one of the first aspects they mention is the support that is available from the Fund.

The Fund maintains a record of staff contacts with potential candidates. At our request, they confirmed direct contact by face to face meeting, telephone and/or email with 180 biofuel companies that are expected to represent the bulk of the deal flow in biofuels. In other words, it appears that the Fund has been in direct contact with most of the companies that could be considered potential candidates for support from the Fund.

Awareness among representatives of the financial community is also important to the Fund. Again, interviews confirmed that the Fund is well known:

- 'People from around the world who are interested in the possibility of a project in Canada mention the Fund. The type of subsidy offered by NGBF (subordinated debt) is very appealing.'
- 'Almost every Canadian company has some intersection with SDTC so that is how we come in contact with the Fund.'
- 'When (clients) talk about Canada, first among first mentions is the support available from the Fund.'
- 'We know (members of NGBF staff) and often meet them at conferences.'

For the future, interview respondents suggest that the Fund should maintain its profile in the community. The Fund should remain sufficiently visible that any new players will encounter the Fund and be aware of its role in Canada.

2. The Fund's Interactions with Project Proponents

i) An Active Investor

The Fund describes its role as that of an 'active investor' and makes three basic points about its involvement with projects:

- From initial contact, the Fund works actively with projects from initial contact to facilitate their development, helping them to avoid unnecessary work and answer their questions as they arise.
- The Fund does not delay progress. The rate of progress is determined by the project. The Fund's reviews and decision-making use the same information that informs the proponents' decisions.
- To date, the Fund has rejected projects only for non-compliance with the eligibility criteria set out in the Funding Agreement. The criteria are discussed at an early stage of the engagement with a potential candidate.

The Fund maintains close contact with proponents of projects that have submitted an IOI and are developing a project with the Fund and with others who may be considering involvement with the Fund and submission of an IOI. The Fund emphasizes its engagement with proponents, discussing possible projects and offering advice on how a project should proceed. For example:

- If a project does not have a pilot or demonstration unit, the Fund advises that this is a requirement for acceptance of an AFF and the project should delay any investment in an IOI or AFF until it has developed a pilot facility.
- If a project does not have a strategic partner, the Fund may encourage the proponent to consider involving a large organization that has experience related to the biofuels field. On some occasions it has introduced projects to potential partners and participated in the initial discussions of a potential project.
- When the AFF is under due diligence review, the Fund convenes meetings with the reviewers, the proponents and Fund staff to review the findings. Discussions focus on

how the project can respond to any gaps or weaknesses in its project plan that have been identified by the review.

- When a project applicant announced that its capital expenditure estimates had increased dramatically and it had decided to cancel the project, the Fund offered to convene a discussion of the situation to ensure that all possible responses to the new information have been explored before the project is withdrawn or cancelled.

ii) Findings from the Evaluation

Proponents who were interviewed confirmed that the Fund played a supportive, participative role. All respondents who were involved with projects supported this approach and agreed that it was well done:

- 'We prefer the Canadian approach, more likely to guide you, assist, help with problems, more iterative, collaborative.'
- 'They want to be part of process.'
- 'The application process may have involved a bit too much back and forth, could streamline, do a bit more quickly. It was sort of a DD process as you move up the value chain. Then you get into the DD, which should be as intensive as it was.'
- 'Very accessible, very helpful very professional. It is difficult to put together projects in this space.'
- 'Rigidity, series of steps, takes time, let's get it done. Faster would be better.'
- 'Excellent set of questions on the AFF, questions that you would expect from a sophisticated investor, protecting Canadian capital.'
- 'They want to participate, only after AFF approval can they do so. They want to participate in the engineering etc. We haven't got there yet but not sure that this is benefit. In this project, blue chip names are partners. If we had a tech company in lead, it would make more sense. Where team is extremely strong, not so sure. Generic model is pretty good for a tech lead, a small proponent.'
- 'DD is superb. It forces discipline on applicants. All the information the Fund requires is the same as strategic investors or banks will require. They want the same level of examination. The Fund is inside tent with the proponent.'
- 'The more rigorous the better. We want to have the strongest possible project, increase the probability of success.'
- 'We know everything we need to know to make a judgment if we want to participate. The Fund could not be more transparent.'
- 'Very professional, cooperative, open to discussion. No delays, but asking questions for an Investment Committee.'

- 'DD a rigorous and detailed process. Process is good, painful and long. We learned a lot from it, would not scale it back. It forced us to look at all aspects of the project, test every aspect of the business model.'
- 'Investment of this magnitude requires rigour to manage especially technology risk. Third party review is valuable to keep the natural enthusiasm of proponents in check.'
- 'In retrospect timing was an issue, not that the Fund process delayed the schedule, it was time for the proponent to do the work. There was much learning for both parties, courtship takes time'

Our interviews confirmed that the process was working well and is valued by project proponents. The principal suggestion for improvement was 'Faster is better'. But when pressed, the comment typically focused on the perceived possibility of delays securing a decision and finalizing contracts before the next phase of project development can begin.

3. Staffing

The review of the Fund's interaction with proponents reflects the high regard that was expressed for the competence and professionalism of the Fund's staff. All of this has been accomplished by two people. Not surprisingly, some proponents expressed concern about the lack of support or backup:

- 'Good people, working effectively.'
- 'Two guys do the work, they could use some help, some mid-level management. They must really be taxed. I don't know how they do it.'
- 'I'm concerned that the level of staffing might get overloaded. Forecasting the pipeline is a problem. The process is much more taxing than the Tech Fund. They need the resources to manage the PAP properly because that is one of the best features of the Fund.'

We understand that the Fund is planning to supplement the Project Finance Committee to deal with the number of decisions anticipated from the PAP process for the anticipated five projects that will be proceeding toward FID. The internal staff may be supplemented by sharing staff from the SD Tech Fund and by adding another member of staff who will be involved with monitoring engineering and construction activities.

While the staff resources are very limited, the performance do date suggests that with these supplements, they are likely adequate to support the Fund in the months ahead.

C. ACHIEVEMENT OF EXPECTED OUTCOMES:

1. The Fund's Public Image: Lack of Progress

The NGBF cannot avoid the history of the biofuels sector: over-promise and under-deliver. It has shared in that history. The first project was well publicized and in no small measure, supported the initiative to establish the Fund. However, after many months spent developing the project, it became apparent that the technology was not ready for commercial application. It needed more work. The project was withdrawn by its sponsors before any monies were requested from the Fund. While no public money was lost, the withdrawal was a clear and visible disappointment. Since then there have been no announcements of progress by any project involved with the NGBF so there has been no public evidence that would dispel the memory of that disappointment.

The image remains today. Our interviews heard a continuing theme that has come to characterize the Fund, lack of progress. Respondents, most of whom who are not directly involved with the program, offered these assessments:

- 'No plants have been built. All the work is at the front end, planning. Part of the problem is industry over-promised, technologies not ready, so they could not move quickly to deliver plants. Those are the facts. We know they are trying, but no concrete results after 5 years? Not even beginning construction of the first plant?'
- 'We made an agreement 5 years ago and there's little to show for it, a large pot of unused money. Is it not time for senior management, industry and government to examine what should happen now? Six years with nothing, should there be another agreement? Should money be re-deployed?'
- 'It's hard to understand what is happening out there. Have heard general issues, get anecdotal evidence. Aware it has not moved as fast as some intended. In Canada we hear about lack of feedstock and lack of investment.'
- 'It's critical that there is no progress to date, but that is where we are.'
- 'They should demonstrate early in game that the Fund was signing, moving. If you don't sign, you have no chance of success. If you sign and don't get success, you at least tried. Did Fund not get enough applications so has not been able to sign anyone?'
- 'Fund does not have an imperative to fund and start projects. Perhaps this is a problem. They pride selves on the most rigorous DD on the street. But is the demonstration of inherently high risk technologies the right place to apply this level of scrutiny? Innovators have a hit and miss ratio they can live with. If they had to be certain, they won't be doing it. Innovation is by nature risky.'

Beyond the awareness that no project has started construction, people outside the immediate group working with the Fund appear to have a limited understanding of the work that has been undertaken. Interview respondents with a detailed knowledge of the biofuels sector expressed concern about the perceived status of the fund. Clearly the Fund should not announce every change in status of a potential project. But for purposes of this evaluation, it is appropriate to summarize the actual progress to date in order to examine the validity of these concerns.

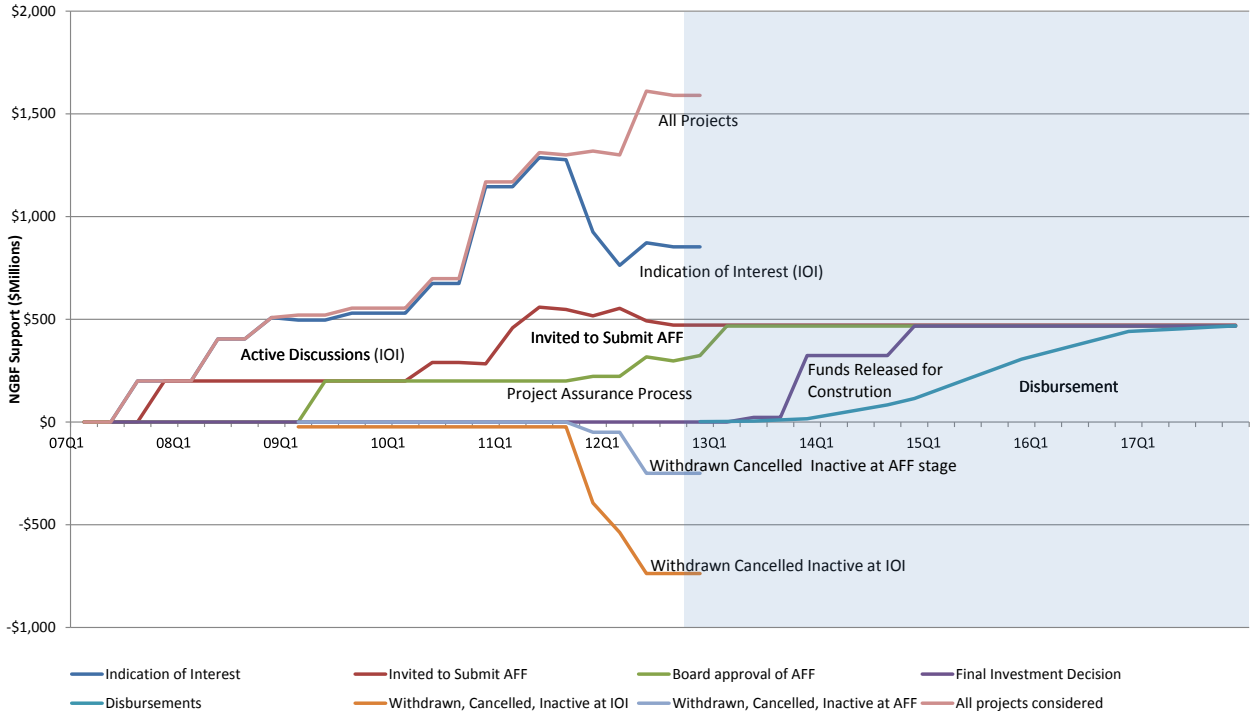
2. Deal Flow: Working to Facilitate First-of-Kind Facilities

i) Progress since 2007

The history of the Fund's interactions with project proponents is complicated. The scope of a project can change and as budgets are refined the amount requested from the Fund can change. As explained in more detail above, projects pass through a number of steps before the plant is commissioned. Exhibit V-1 uses these key transitions in the process to summarize the history of the Fund's deal flow. The history of the Fund's interactions with potential projects, its deal flow, is recorded in the clear area to the left of the chart. The shaded area shows the current projections of progress for the five most advanced projects.

Since its inception, the Fund has worked with a number of proponents to develop potential projects. To date, 17 of those projects, representing about $1.6 billion in potential contributions from the Fund ($6.1 billion total investment), have been brought to the attention of the Board of Directors. The exhibit shows the total value of potential commitments to projects that have been engaged with the fund and distributes them into the various stages of development described above.

Exhibit V-1 NGBF Deal Flow Actuals and Projections to 2017



Source: Updates presented to the SDTC Board of Directors

To explain the exhibit, we should trace the history from 2007 when the Fund was established. The first project quickly moved through initial discussions and by 2008 was preparing an AFF. During 2008 a number of potential projects opened discussions with the Fund. By the end of the year, six projects, representing $500 million of potential commitments by the Fund ($1.6 billion total capital cost), were engaged with the Fund. All of the projects

were at an early stage. Only the first project had completed pre-commercial demonstrations and therefore they did not yet qualify to prepare an AFF.

Given the state of the economy and financial markets at that time, it is not surprising that in the period to mid-2010, only one proponent introduced a new project to the Fund and those in active discussions progressed slowly.

In 2010 progress resumed. A stream of new proponents came forward. By the end of 2010 the total potential contribution had risen to about $1.2 billion. More projects passed key milestones, a number began preparing an AFF and the most advanced entered the PAP. As projects progressed and developed a more complete and accurate picture of the proposed plant some identified problems. For example:

- Updated plans increased estimated capital cost beyond the level that could be supported by projected revenue.
- Results from continuing work at the demonstration site identified problems with the technology that could not be accommodated in the proposed plant
- Proponents could not identify private investors willing to commit capital to the project.
- The project could not identify a strategy for developing the technology and therefore could not describe a concept for a specific plant. As a result they could not be invited to prepare an AFF.

Given these circumstances, the proponents took a variety of stances. They cancelled the project completely, withdrew their project from discussions with the Fund, or simply ceased to actively pursue development of the project. It is important to note that proponents took all of these decisions. The Fund has not rejected a project that satisfied its eligibility criteria. In the examples cited above and others, the Fund has worked with proponent, actively seeking solutions to the emerging problems. It is understood that the proponent is welcome to re-open discussions with the Fund, should the proponent wish to pursue the approval process.

We have grouped these ‘problem’ projects into a two categories, depending on whether the issues emerged during the initial discussions with the Fund or after the project had been invited to submit an AFF. To date, five projects moved to this category during their initial discussions at the IOI stage and three while preparing their AFF. Both groups are plotted with negative values. Today they account for $738 million of potential commitments and the value of currently active projects is $847 million.

As noted above, government programs that provide capital support typically issue terms of reference for a competition, review proposals and announce the winners, committing public funds for completion of their project. This suggests an interesting question: what would have happened if the Fund had followed the model used by government and awarded full support after a competition? Assume for sake of argument that the Fund called for proposals and retained the condition that the technology must have information from extended runs in a demonstration site (a more stringent requirement than was applied by any other program we reviewed.) As of today NGBF would have announced full commitment of funds for the first three projects and the fourth could be announced if the AFF is approved at the November meeting of the SDTC Board.

ii) Current Status

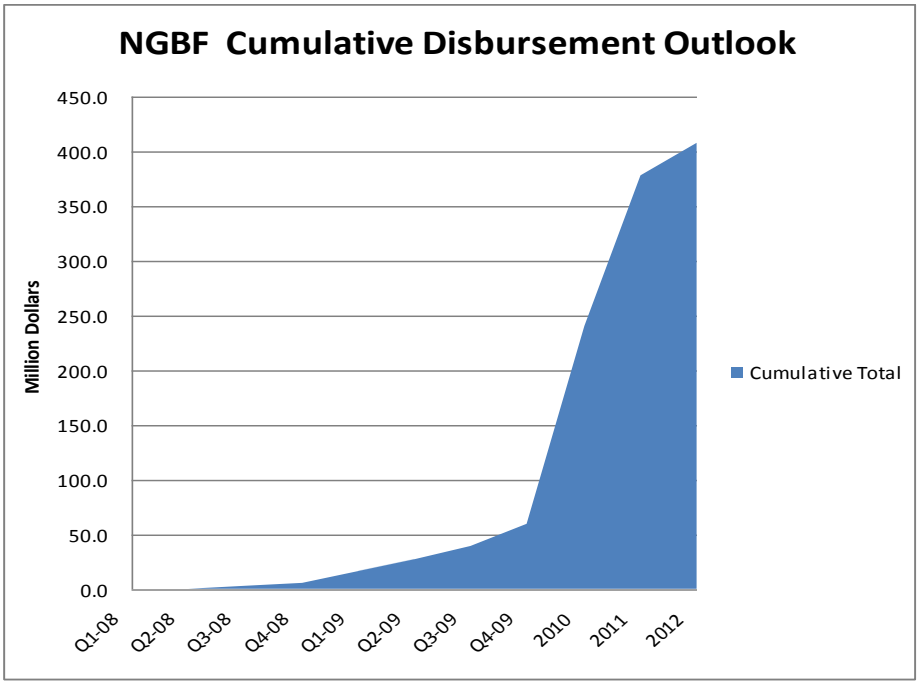
As this report is written, three projects whose potential commitments total about $297 million, have completed the due diligence review of the AFF and were approved by the SDTC Board for support to complete the PAP. A further two projects ($170 million potential commitments) are preparing an AFF, the first is scheduled to be presented to the Board in November 2012 and second in the 2nd quarter of 2013. The potential commitments for the five plants account for the total amount available from the Fund.

Given the history of the biofuels sector and the history of the Fund, we should not assume that all five projects will proceed to production on schedule. Should any of the projects not proceed or be down-sized, a further group of three proponents, whose potential projects representing potential commitments of $380 million, have submitted Indications of Interest and are in active discussions with the Fund to develop their projects. They represent potential candidates to move ahead in the process, taking the place of any project that encounters difficulties.

iii) A Snapshot of the Fund's situation mid-2008

As outlined above, by mid-2008 the Fund was working with five projects whose potential commitments matched the resources available to the Fund. As noted, all were at early stages in their development. However, the projections for those projects suggested the Fund would proceed fairly quickly to disburse a substantial share of its funds. Exhibit V-2 shows the cumulative disbursement forecast by active projects in June of 2008 that was submitted to the SDTC Board of Directors.

Exhibit V-2 Projected Disbursement, June 2008



Source: Update presented to the SDTC Board of Directors June 2008

Of the five projects included in the projection, two are currently completing detailed designs with support from the Fund and are anticipating FIDs in the next months.

iv) Projected Outcomes from the Fund

The basic mission of the Fund is to facilitate the establishment of first-of-kind commercial-scale next-generation biofuel plants. The Funding Agreement requires that the disbursements must be complete by March 2017. The current status of the Fund supports a projection that this should be accomplished. Exhibit V-1, above, shows current projections for the five projects most advanced projects. The Final Investment Decision (FID) for the first project, which will allow construction to begin, is scheduled for the 2nd quarter of 2013. Three projects anticipate their FID in the 4th quarter of 2013 and the last for 4th quarter of 2014. With construction proceeding after the FID, project budgets call for the total Fund's capital to be disbursed before the end date set out in the Funding Agreement. The first plant is scheduled to begin commissioning in 2015, the next three follow about a year later and the last in 2017. The combined production capacity for the five plants totals 342 million litres of biofuel per year.

3. Assessment of Progress to Date

A key concern for the evaluation is assessing the performance represented by the current status of the NGBF. It is too early to judge outcomes in terms of completed projects. The Fund has interacted with 17 proponents and there have been reports of change in status showing both progress and problems. Is this acceptable? Could the Fund have done better? These are difficult questions. However the reasonable concerns about the fund expressed by those we interviewed suggest we should attempt to provide some context for consideration of the Fund's performance to date. One approach that could offer some perspective on the question is to compare the Fund's status to the progress and results of programs playing a similar role. The following sections offer two such comparisons.

i) Canadian Programs

There are no close comparators available in Canada. NGBF is the only large capital support initiative focused on next-generation biofuels. The some provincial programs are prepared to offer support but none has a leadership role, soliciting projects and taking them to commercial-scale operations.

However there are some parallels between Natural Resource Canada's Ethanol Expansion Program (EEP) and EcoAgriculture Biofuels Capital Initiative (EcoABC), the capital grant programs for first-generation biofuels administered by Natural Resource Canada and Agriculture and Agrifood Canada (AAFC). These initiatives provided repayable contributions for establishing grain ethanol plants, building Canadian capacity in a technology that was well known. We note significant differences between the ethanol programs and the NGBF: beyond expanding Canadian capacity the EcoABC created an opportunity for farmers to invest in grain ethanol plants; both programs operate within a departmental budget so it is relatively easy to change budget levels and deadlines; and the new facilities could count on production subsidies

from ecoEBF. Given these caveats, we consider the comparison to provide some Canadian context to the progress recorded by the NGBF.

The Canadian programs mirrored initiatives in other countries. Worldwide production of grain ethanol grew rapidly from 2000, doubling by 2005 (BIOCAP Canada, 2006) and in the United States the growth rate was even higher, 240% of the 2000 level. (Renewable Fuels Association, 2012). During this period the EEP lagged well behind its planned expenditures. EEP was allocated $100 million between 2003-04 and 2005-06 with planned expenditure of $60 million in 2003-04. A recent evaluation shows that less than $1 million was disbursed during that year and it took until 2006-07 for the full amount to be allocated, roughly $30 million per year over each of the final three years (NRCAN, 2012).

The ecoABC was established under the Renewable Fuel Strategy in 2007 to provide an opportunity for agricultural producers to participate in the renewable transportation fuel production industry. The program initially provided $200 million over four years in the form of repayable contribution toward the cost of facilities that used agricultural product as feedstocks. During this period the expansion of grain ethanol capacity in the United States proceeded apace. Between 2005 and 2010 production grew 330%. The ecoABC program has been extended by two years to September 30 2012 to allow projects more time to complete construction and qualify. The budget was re-profiled to about $160 million. A recent evaluation reported that ecoABC had signed agreements for $46.8 million and committed a further $32.5 million to two additional projects (Agriculture and Agri-Food Canada, 2011). If these funds are committed and disbursed, the ecoABC will have used 39.7% of its original budget or 49% of the reprofiled amount.

Overall, it appears that before the Renewable Fuel Strategy introduced operating subsidies and announced the intention to implement the Renewable Fuel Standard, the expansion of first-generation ethanol plants under the EEP was slow. Since the strategy was rolled out in 2006, the commitment of funds by ecoABC still lagged well behind projections. Compared these outcomes, the NGBF rate of progress is not out of line. The NGBF has lagged well behind its initial internal projections but its current plans call for full disbursement of the available funds well within the target date specified in the Funding Agreement. However we recognize that the comparison is relatively weak. The deadline for the NGBF is established in a legal agreement between the government and SDTC while the programs worked within the malleable structure of their department's budgets.

ii) US Department of Energy

In 2006 the Energy Independence and Security Act (EISA) mandated the US Department of Energy to conduct a competition for funding to support the development of biorefineries in the United States. The industry responded with about 100 proposals. These were 'down-selected' to about 10 judged to be 'above the line' and subjected to 'merit reviews' conducted by a small number of non-conflicted outside experts. The department entered award negotiations with the top candidates and finalized awards to six projects. We understand the proposals were judged on the basis of the submitted documents. There was not sufficient time to conduct site visits or to discuss the proposals with proponents

The review of the proposals for the biorefinery competition revealed that many of the proposers were at an early stage in the development of their technology. In 2007 the department held another competition and selected seven proposals to build demonstration plants at 10% of commercial size. The next year another competition made 18 awards for further pilot and demonstration projects. Note that in Canada, since it was established in 2002 the SD Tech Fund has supported pilot or demonstration installations for a number of biotechnologies.

We established the status of the DOE projects from our review of publications and interviews with department staff. Current reports show that five commercial-scale biorefineries are receiving funds (EERE, *Integrated Biorefineries*, 2012) whereas only three of the projects selected in the biorefinery competition are still active. However the department includes the two completed demonstration sites in its count, commenting that those projects are relatively large and in the department's view, qualify as commercial-scale. (As reported above, the NGBF requires that a project has at least 1000 hours of integrated continuous operation of a demonstration plant with reasonable scale-up risk in order to qualify as project-ready.) The US experience parallels that of the NGBF in that initial progress was substantially delayed by the financial crisis and by the early stage of development of the next-generation technologies..

Exhibit V-3 offers an overview of the results for the 17 NGBF projects that are represented in Exhibit V-1 above. To parallel the data from DOE, we also show the related SD Tech Fund biofuel projects, showing only those technologies that meet the NGBF terms of reference. In other words, we exclude complementary technologies that would enhance a biofuel technology as a 'bolt-on', technologies that are not second-generation and projects that do not satisfy the complete production pathway even if they displace a fossil fuel (for example municipal waste to syngas to a diesel generator producing electricity for the grid). The exhibit summarizes the results for the three DOE competitions, the shaded area for the 2008 and 2009 competitions indicates that the status was not detailed, the projects are 'still around, some going well, some not'. For both SDTC and DOE the large bold values identify the projects involved in the comparison of progress.

We should note that all of the DOE projects selected through a competition received DOE support for their subsequent development. On this basis, all DOE projects have an incentive to remain associated with the department's program even as they address any problems that have occurred with their project. This appears to be the case with a number of projects from the 2008 and 2009 competitions and one biorefinery from the 2007 competition. Only the five NGBF projects in the design stage would be in a similar position. The NGBF projects have advanced individually from initial discussion to detailed design at a pace that has been determined by their ability to complete the work and meet acceptable standards of technical performance and financial results. They receive support for their commercial-scale project only after passing a due diligence review of their project plans, usually submitted in an Application for Funding. However as noted above, Canadian projects that are at an early stage in their development can apply for support for their pilot or demonstration-scale installations from SDTC's SD Tech Fund.

Exhibit V-3 Current Status of Biofuel Projects involved with SDTC and DOE

	Sustainable Development Technology Canada		Department of Energy		
	NGBF	SD Tech Fund Biofuel Projects	Biorefineries	Demonstrations and Pilots	
Stage of the Project		Demonstrations and Pilots	2007	2008	2009
Completed construction		6		**1**	**1**
Passed FID		6	**1**		
Design	**5**	2	**1**	2	15
Preparing design	3				
On hold, inactive	6		**1**		
Cancelled, withdrawn	3	2	3	4	
Total	17	16	6	7	16

Source: NGBF Updates presented to the SDTC Board of Directors, SD Tech Fund Funded Projects Portfolio and Interviews with DOE officials

The comparison suggests that progress of projects supported by the DOE is quite comparable to that of NGBF supported projects. The two completed DOE projects are smaller but still important to the department's overall objectives. One of the biorefinery from the 2007 program is scheduled to begin commissioning in the next few months. The second has not yet been released for construction and the third is dormant awaiting the recruitment of a strategic investor. If both are successfully completed, the department will be able to count five operational biorefineries emerging from its programs. NGBF is currently working with five commercial-scale projects that are advancing toward construction and completion. Its most advanced is scheduled for FID mid-2013 so recognizing that the NGBF was launched about a year after the biorefinery program was mandated, the first DOE plant is about one year ahead of the first NGBF plant.. If any of the five plants NGBF plants should falter the Fund has the option of advancing a replacement from those projects that are developing proposals. Overall the DOE projects are slightly more advanced, smaller in scale and fewer in number but all of these differences are small, given the scale of the programs.

The comparison should also take into account the public support for these projects. DOE will invest about $500 million in capital support (counting $389 million for the biorefinery program and a share of the two demonstration programs associated with the two completed demonstrations.) As well, when the plants are completed they can count on the marketplace supports outlined above including segregated standards for cellulosic biofuels in the RFS, tax incentives for fuel produced and to establish a floor price for the product, etc. The NGBF projects will receive about $500 million in capital support but that is the only federal support that is currently available. Their planning and decision making can reflect no Canadian marketplace supports that are comparable to those available to the US projects. We should note that some provincial programs supporting next-generation fuels are available in Quebec, Alberta and British Colombia.

Overall we judge this comparison to be favourable for the NGBF. It has achieved about the same progress as the DOE, invested about the same amount in capital supports for its projects, is actively working toward five commercial-scale projects compared to four (plus one dormant project), two of which are graduates from the demonstration program. And this has been accomplished in the absence of the marketplace supports that are available to the DOE projects.

4. Conclusion: The NGBF has Made Remarkable Progress

Clearly, the Fund has progressed more slowly than was at first expected. The financial crisis led to about a year of very slow progress. The state of development of the technologies has been a limiting factor. The Fund employed the discretion it was granted in the Funding Agreement, proceeding carefully, inviting projects to submit applications only when they are judged to be project-ready, working with proponents to identify potential risks for projects and to minimize them. A number of projects have been withdrawn as proponents realized that the identified risks could not be accommodated in the existing project plan. The continuing projects have proceeded at the pace they can sustain.

Our research leads to a conclusion that the NGBF has performed remarkably well. The rate of progress by the NGBF is generally in line with that of the somewhat similar programs to expand Canadian capacity to produce grain ethanol. Given the market supports that are available to the biofuel projects being developed in the United States, the NGBF progress to date compares favourably with that of the DOE's biorefinery program. We judge that its only weakness springs from the cautious approach adopted in the PAP which releases the finds for construction only when all plans are complete and approved by the partners. This typically would occur at least one year after a public program would announce support for projects that were successful in a competition. The Fund's silence appears to have been interpreted as lack of progress and the Fund has been criticized, in our view unfairly, as a result.

D. REINVESTMENT OF NGBF FUNDS

The Funding Agreement calls for each interim evaluation to report on the reinvestment and repayment collection experience. This will be a much more important subject in subsequent interim evaluations when plants that had been supported by the Fund are in operation and may be repaying the Fund's contribution. At this point in the Fund's history, we can simply report on the re-investment of the first conditional grant from government. Exhibit V-4 shows the position at the end of fiscal year 2011.

The allocation of funds to the classes of investments follows the guidelines set out in the Funding Agreement. We understand that the annual yield from these investments was 0.8%.

Exhibit V-4 NGBF Reinvestment Experience

	NGBF Asset Allocation Ratings Breakdown		
	Sum of Market Value		
Rating	Government	Other	Totals
AAA	$19,539,833	$0	$19,539,833
AA	$0	$25,613,103	$25,613,103
Money market securities	$12,639,688	$0	$12,639,688
Total	$32,179,521	$25,613,103	$57,792,624

		% Breakdown	
Rating	Current %	Maximum	Available %
Other A	0%	20%	20%
Other AA	44%	70%	26%
Other AAA	0%	80%	80%
Government AA	0%	No Limit	No Limit
Government AAA	34%	No Limit	No Limit
Money market securities	22%	No Limit	No Limit
Totals	100%	0%	0%

Source: SDTC 2011 Annual Report

E. SUGGESTIONS FOR IMPROVEMENT

1. Sharing Information with Government

As discussed in the interim evaluations of the SD Tech Fund, the Foundation is an unusual structure in the Government of Canada. It works at arm's length from government, reporting regularly to representatives of the two responsible departments.

From the departmental perspective, this structure means the department faces a lack of information. Confidentiality constraints prohibit discussion of the specifics of projects until they enter the PAP so the Fund presents summary statistics general overviews of the situation. This means the department has less information about information gaps, feasibility, business modeling and is concerned that there may be unrecognized needs that the department could work to address. Departmental officials see little prospect that this will change until the next-generation plants are operating and accessible to the department. This situation contrasts sharply with the department's experience with the first-generation sector where the department delivered capital incentives and production support to ethanol producers and developed relationships with the industry. It can conduct analyses, assess policy needs and address the requirements of the industry.

Projects have a very different view of Fund and the SDTC foundation. As discussed above, projects welcome the close involvement of the Fund in its role as an active investor.

They value the prompt responses and close interaction the Fund provides. Those proponents who have had experience with direct government supports strongly prefer the Fund's approach. They contrast the 'active investor' to the use of competitive proposals which is often characterized as a 'black box'. The adjudication of proposals is seen as often arbitrary and providing no value added, none of the improvement in the project or learning that they have seen in the NGBF process. Beyond the immediate contacts with the Fund, they cited other advantages, fewer people having access to their intellectual property and to the nuances of their corporate strategy that come into play when investing in new technology. They find other advantages to working with a foundation, the money is appropriated so they don't face lengthy delays while funding requests are processed by government, decisions can be taken independent of elections, cabinet shuffles, and other interruptions that reflect the internal workings of a national government, they do not have to deal with 'an army of bureaucrats'.

While we judge that both views have merit, we suggest that the departments and the Foundation should seek ways to address the need to share information and more generally, to share a broad understanding of the next-generation biofuels sector. A proponent put it well:

- 'As an active investor, the Fund has been pursuing opportunities, advocating Canada as a good place to do business. This has benefits. The Fund scans the industry with an inside track. A new industry is built on IP, so there is a low level of collaboration. The Fund has a unique perspective because it talks to many key people in the industry.'

A simple approach builds on the comments of some departmental representatives:

- 'The Fund probably has people who are intimately aware of how things going, able to discuss in context of overall policy direction. Nextgen needs an advocate at policy table, explain, justify how they fit in future, as part of policy construct.'
- 'SDTC is a dutiful implementer. Government interaction needs a stronger role. If the Fund believes we are moving in right direction, it should take an advocacy role and duty to truthfully understand how and whether Nextgen integrates with other policy and programs. How other jurisdictions handle it, the Fund should able to speak to that, raise its profile so it is inevitable, not just nice to do.'

Our suggestion: When a department needs information on the sector, it should ask the Fund. Pose its questions to the Fund. Or invite the Fund to participate in policy discussions, bringing to the table its expertise and detailed knowledge of the sector and contributing to the discussion.

We have noted that the Fund operates with an extremely small staff so it could not undertake tasks that would require significant amounts of preparation time or analysis. But its participation could help government's policy discussions to be well informed about the current status, challenges and needs of the next-generation biofuels.

This would likely be a short-term arrangement until the first plants are completed and begin commissioning and production. At that time, departments should have direct access, particularly if they are responsible for programs that interact with and support the new plants.

2. Faster is Better

We expected to hear proponents repeating 'faster is better' as an overall comment on their work with the Fund, but that was not the case. Proponents want to proceed at their pace, not be held up by the Fund or anyone else. In the view of interview respondents, they were able to do just that:

- 'Through the whole process, we have been the bottleneck, there was no hold-up from the Fund.'
- 'It takes a long time to develop the project but we have been able to proceed as fast as we wanted.'

When we explored this question, some concerns emerged that were anticipating possible problems that could emerge in the future while others were looking for clarity, perhaps even for more direct assistance:

- 'They need to be more time efficient, reviewing reports and granting approvals. The Board only meetings every 3 months. It could be more flexible, efficient.'
- 'A private company can get approval in week. We don't want to wait months for a decision.'
- 'We would like to see a quicker preliminary process, quick, and easy, then assign a staff member to shepherd you through the process, work with you sooner to guide to the final application. Then may drop off as management takes the lead.'
- 'Expectations for reporting between stages seems bureaucratic, sometimes it is not clear what is wanted.'

In general, proponents commented that the Fund responds quickly and imposes minimal delays. However it appears there is some room for improvement in terms of the clarity of its expectations, particularly when a proponent is uncertain about the appropriate response to a requirement. While staff resources are very limited, these comments suggest the Fund should consider a more conscious effort to tailor its involvement to the needs and concerns of proponents, particularly where they have relatively little experience with the process or they express concerns or seek guidance. The Fund should not manage a project, but it might give more guidance and support, transferring skills and building the competence of a proponent's team.

3. Clarity on the Terms of the Funding Contract

Some proponents would like to have more clarity about some of the Fund's requirements, particularly the terms of repayment

- 'Repayment: a blessing and a curse. Free cash flow repayment is an interest free loan. Repayment over 10 year is more beneficial. But all of the terms and conditions are subject to final Funding Agreement that comes later in the process. So when we are planning, we have to use the most conservative interpretation. It is favourable not fantastic. 40% free cash flow to one partner can deteriorate the economics.'

- 'We would more certainty earlier in the process on the Fund's share of capex. The concern is that if the Fund is oversubscribed, it might allocate differently than we have planned. It would be better if the Fund gave more certainty, if you get to end date and deliver on these promises, you will get what you expect.'

These issues certainly look beyond any experience to date. However these uncertainties appear valid. The Funding Agreement may constrain the Fund's ability to respond to these points. If so, it would be helpful if that were made clear. If the Fund has flexibility to respond, giving some guidance on questions such as these would be helpful.

4. Address the Image Issue.

The Fund has dealt with a tough choice. Announce early and be prepared to suffer the consequences of project that does not proceed or announce late, when all the partners in a project agree to commit to release funds for construction. The latter has been the mode followed by the Fund. It has led to a significant challenge posed by its image, no progress after 5 years, ostensibly sitting on a large pot of money and doing nothing with it.

If it were to follow the general approach taken by similar government programs and announce 'winners' early on the process, likely at the end of Phase 1 and acceptance of a recommendation to support Phase 2 the Fund would face the probability of negative publicity when a project does not proceed to completion.. An announcement of a conditional intention to support the project to completion and a firm commitment to support detailed design is of little interest to the press or to potential investors who want to see a solid commitment to support to completion. Even if the decision followed the pattern to date and was initiated by the proponent, not the fund, the adverse outcome would likely adhere to the Fund.

We suggest the Fund consider communicating its overall position, perhaps in a manner akin to the deal flow discussion above. While lacking specifics on projects, it may provide an avenue to communicate the considerable progress made to date and the likelihood of achieving the Fund's objective, to facilitate first-of-kind facilities.

F. SUSTAINABLE DEVELOPMENT AND MARKET IMPACTS

The Funding Agreement for the NGBF specifies that the interim evaluations should include an estimation of the Sustainable Development Impacts and Market Impacts of Funded Projects as estimated as of the date of the evaluation. We respond to this requirement by presenting a cost-benefit analysis of the five projects currently engaged in the Project Assurance Process, moving toward Final Investment Decisions to authorize construction to begin. These five projects, if fully implemented, would account for all NGBF funding and as such this represents an assessment of the overall NGBF impact.

This section responds to the evaluation requirement to assess Achievement of Expected Outcomes. The specified outcome in the Funding agreement is to support the development and construction of first-of-kind plants producing next generation biofuels. This report provides our

assessment of outcome achievement in the context of estimates of market sales and environmental impacts of five first-of-kind plants that are currently progressing toward construction. This approach takes into account SDTC costs, all capital and related costs of the proponents and uses estimates of sales and environmental impacts to develop quantitative estimates of outcome achievement.

1. Why Use Cost-Benefit Analysis?

For this evaluation, we employ a cost-benefit analysis model to assess the impacts of the NGBF. In reviews of investments in new technologies, the central underlying question frequently involves a comparison of what the investments achieve relative to their cost. This means that cost-benefit perspectives are being used implicitly. Explicit use of cost-benefit analysis makes the assessment clearer and more meaningful and provides important information for decision makers.

Cost-benefit analysis is a tool for better public sector decision-making. Private sector organizations routinely carry out detailed financial studies related to their decisions to commit new funds to a project. They also review rates of return on past investments as a guide to future investment decisions and in general, consider only those impacts that generate revenue or cost streams for the organization itself. The major difference between private sector financial assessments and social cost-benefit analysis is in their inclusiveness. In principle, public sector decision-makers should consider all of the positive and negative impacts of the expenditures that are being reviewed. (Positive impacts are benefits while negative impacts are costs) All benefits to members of society, not just benefits to proponents of programs like SDTC, should be taken into account. In other words, cost-benefit analysis goes beyond a narrow financial perspective to capture all of the impacts, positive and negative, of pursuing particular courses of action such as providing support for new environmental technologies.

Cost-benefit analysis is simply an organized way of assembling and presenting data on the impacts of a set of activities. Investment expenditures can be assessed in terms of their positive impacts relative to their costs when these are measurable. In cases in which some of the important impacts cannot be assessed quantitatively, cost-benefit analysis is still an effective organizing framework to assist decision-makers.

Cost-benefit analysis converts the impacts of a policy or program into dollar units. Under the assumptions of the benefit-cost model the dollar magnitudes reflect levels of well-being for members of society. Dollars are being used as a common yardstick to measure well-being as perceived by members of society. Policies or programs with a greater excess of benefits over costs would be preferred by members of society to alternatives with fewer benefits relative to costs. In the case of support for environmental technologies, a key challenge is to develop estimates of the relationship between well-being and what members of society are willing to pay for the impacts (cleaner air, for example) associated with the new technologies. Economic analysis provides information on benefits and costs to allow policy options to be compared and ranked.

Cost-benefit assessments are used both when introducing new programs and when reviewing existing ones. In the case of benefits failing to cover costs, the results of expenditure

reviews may provide indicators of why the program is not performing as originally anticipated. Even if already positive, program evaluation results can be used to determine if there are changes that might improve the cost-benefit picture. The use of a benefit-cost framework allows analysts to demonstrate that costs will be more than offset by the positive benefits of the initiative.

The cost-benefit model for the NGBF was originally developed by Smith and Cunningham in December 2007 to assess projects in the SD Tech Fund. This model is described in the report, *Implementing a Cost-Benefit Framework for Sustainable Development Technology Canada Final Report*. Six parameters drive the valuation of costs and benefits in the model:

- Value of GHG Emissions Reductions ($ per tonne of C02 reduced)
- Probability of Achieving 100% of Sales Projections: Sales Projections (*P1*)
- Value of Ancillary Environmental Benefits ($ per tonne of C02 reduced)
- Probability of Achieving 100% of GHG Reductions: GHG Reduction Projections (*P2*)
- Incrementality
- Social Discount Rate *(SDR*)

The values of these parameters that are also used in this assessment of the NGBF were developed from our review of the relevant environmental economics research literature and data for the five SDTC-funded NGBF projects. The current evaluation uses parameter estimates that have been refined and updated based on the more recent research literature and the current data on projects. Each variable is explained below including any changes to assumptions about that parameter value used in the model. All dollar values are in 2011 Canadian dollars. Parameters used in the SD Tech Fund evaluation were in 2005 Canadian dollars. The values used in this study, were increased to 2011 dollar values using the increase in the Statistics Canada Consumer Price Index, between 2005 and 2011.

2. Value of GHG Emission Reductions

The benchmark value of $13.45/tonne of C02 is consistent with the mean of the estimates from 100 studies reviewed by the IPCC in their 2007 report. Subsequent studies have confirmed the validity of this range. The data have been converted to 2011 Canadian dollars. An early version of this model had a large range of estimates reflecting uncertainty in the literature about the appropriate social cost of carbon. We have revisited the literature on social cost of carbon estimates and updated the high value for this parameter, in order to have a smaller and more practical range of estimates for the purposes of estimating NGBF project benefits. By reducing the high value we make benefit estimates lower (i.e. more conservative) than in the previous version of the model.

Tol (2005) provides an extensive literature review and meta-analysis of existing studies that estimate the social cost of carbon, and this study was also a source for estimates in the IPCC (2007) research. To reconsider our estimates for carbon valuation, we re-examined the distribution of estimates in Tol's meta-analysis. He distinguishes between peer-reviewed and non-peer-reviewed estimates, and emphasizes that peer-reviewed estimates have less uncertainty surrounding them. The mean and low estimates reported in Tol (2005) are consistent with our

benchmark and low estimates of $13.45/tonne of C02 and $6.75/tonne of C02. To obtain a reasonable high estimate for our sensitivity analysis, we use the 75th percentile in the distribution peer-reviewed estimates reported by Tol (2005). This approach gives a high estimate equivalent to about $22.40/tonne of C02 in 2011 Canadian dollars.

3. CAC Ancillary Benefits

Burtraw and Toman (1997, 2001) describe how GHG reductions can also generate reductions in other, conventional pollutants, and consequently reduce damage to human health and the environment. They also point out, however, that ancillary benefits are often localized and depend on the pollutant, the exposures of human populations to the pollutant, and the presence of existing controls on these pollutants.

They argue that almost all of the ancillary benefits in the U.S. would result from reductions in "criteria" air pollutants as defined in the U.S. Clean Air Act. They focus on the criteria air pollutants from fossil fuel use:

- Sulphur dioxide (SOx)
- Nitrogen oxides (NOx)
- Carbon monoxide (CO)
- Particulate matter (PM)
- Tropospheric ozone (O3)
- Lead

The criteria air pollutants have well documented negative effects on human health, including pulmonary disorders and cardiovascular problems. Thus as GHG reductions occur, related reductions in these pollutants will produce ancillary benefits, primarily in the form of reduced health damage. Ecosystem damage can also occur if CAC pollutants occur in high enough concentrations. The 1997 Burtraw and Toman estimates indicate that ancillary benefits could average about 30% of the value of GHG reductions, i.e. $3 per tonne value of ancillary benefits for a $10 per tonne GHG average benefit from carbon reduction. Larger than average benefits would occur with greater population density and higher levels of exposure to damages from criteria air pollutants.

Our cost-benefit analysis model uses the method of Burtraw and Toman which links ancillary CAC benefits to the amounts of GHG emission reductions. We employ a baseline value of $5.60 per tonne of GHG emissions reductions to calculate the value of ancillary environmental benefits. A range of $3.40 to $11.20 per tonne is used for the sensitivity analysis for the ancillary benefits parameter. It is important to note that the literature on criteria air contaminant impacts of biofuels-specifically ethanol is mixed. Some of this literature indicates that biofuels may increase the difficult smog component of air pollution. Based on the conclusions in the Expert Panel report for the UK Department for Environment, Food and Rural

Affairs (DEFRA, 2011) that there is no net ethanol impact, we have not credited projects with this benefit except in the case of a substitute for heating oil. This is an area of continuing research and analysis. We have adopted the conservative assumption of no health benefits in this report.

4. Incrementality

Incrementality refers to the extent to which the supported projects would have been carried out in the absence of the SDTC funding. Recent results from the survey of key informants asked questions about what these respondents think would have happened had the NGBF project not been funded. The results from these interviews suggest strongly that none of these projects would have proceeded without NGBF funding. As a result, the benchmark value is 1.0.

A further issue relates to attribution of estimated benefits. We recognize the complex issues involved in this distinction. The question is the extent to which NGBF should get credit for benefits from its projects, particularly for GHG reductions in the context of Renewable Fuels Standards that mandate the use of biofuels. These standards, however, do not mandate the use of next generation biofuels. Further, the installed capacity to produce first-generation fuels is almost sufficient to supply the volume of ethanol required to meet the current standards for Canadian gasoline. According to an agreement between the departments of government, emission reductions from any fuels produced from the first-of-kind plants will be attributed to the existing regulations. Since the first-generation fuel will almost satisfy the requirement of the regulation, our analysis assumes that all of the next-generation benefits can be attributed to the Fund.

5. Probability of Success: Sales Projections (*P1*)

SDTC has provided sales and output quantity projections for funded projects. Sales revenues are used to estimate the private economic benefits from the project. The output quantities determine the amount of GHG emissions reductions that are expected to result from adoption of the NGBF-funded technologies. There is, of course, a large amount of uncertainty around any sales projections for new technologies. Therefore sales projections are all reduced using a parameter to reflect the probability that the sales forecasted will actually occur, *P1*. When projects are at the Final Investment Decision stage, we estimate that the typical experience for those using conventional technology is P1= 90%. In this study, we use 85% for all first-of-kind projects in the NGBF pipeline.

R&D projects and related successful new technologies typically earn economic rents (the economic term for profits above a continuing normal level.) These rents reflect the uniqueness of the new products or innovations. In our assessment of the SD Tech Fund, we used a value of 5% of sales as our estimate of the economic rents component of overall social benefits. However, in the case of the first-of-kind NGBF plants, we have made the more conservative assumption that these plants earn no economic rents because the initial plants will have unanticipated costs of beginning operations that subsequent plants will not face. We assume that the follow-on plants learn from the first-of-kind and as a result we attribute economic rents of

5% of sales to them. This is our estimate of the economic rents (private benefits) net of all initial and continuing costs of NGBF plants.

6. Probability of Success: GHG Projections (*P2*)

The probability of a project's success also depends on the technical success of the technology, in particular the probability that the new technology actually generates the GHG emissions reductions that have been estimated. In the cost-benefit model this probability of success is captured in a parameter *P2*. The cost-benefit model applies the *P2* value to reduce the projected GHG emissions reductions in order to reflect the risk that the technology does not reduce GHG emissions to the extent forecast. For P2, we concluded that this value should be quite accurately predicted by the performance of the demonstration project, which must have operated for 2000 hours on a continuous production basis before the NGBF will give final approval. As a result, we have used P2=95% , allowing some slippage from problems with scale-up from demonstration to full operation, This high value also reflects the fact that if sales estimates are met, biofuels will perform as estimated by GHGenius.

As can be seen GHG emission reductions projections are multiplied by P2, but they are also multiplied by *P1*, the probability of the sales being made. This reduces the net environmental benefits estimates because these benefits clearly depend on outputs being produced and sold. The projected environmental benefits are calculated as follows:

P1 x *Projected Unit Sales* x *P2* x *Expected Per-Unit Reductions in GHG*

7. Other Impacts

Biodiversity impacts can be considered as a broad category that includes possible negative water, soil and habitat impacts of producing biofuels and particularly of sourcing inputs. These are potentially negative but the literature does not provide sufficient information on possible magnitudes to incorporate in the quantitative analysis.

8. Social Discount Rate

The standard cost-benefit methodology involves estimating the dollar values of costs and benefits over the time horizon that is considered to be appropriate for the full costs and benefits to be realized. In some cases, such as economic or health impacts, benefits may not be realized until many years later. To make a comparison of costs and benefits the estimated values for each year are discounted back to the reference year (usually the current year) using a social discount rate.

Typically, one discount rate is applied to all estimated future costs and benefits. Recently, however, there is some debate as to whether environmental benefits should be discounted at a different social discount rate than that used for other types of benefits and for overall costs. Weitzman (1998) demonstrated that if future outcomes are uncertain, the lowest possible nonnegative discount rate should be used to discount far-future benefits. Based on the recent literature and published reactions to the Stern Review by leading researchers, we employ a

benchmark discount rate of 3.5%, with sensitivity analysis at 2% and 5%. These values incorporate Weitzman's recommendations for the period under consideration based on his survey results.

The analysis also includes an annual growth rate of environmental benefits of 2%. This is related to the Weitzman view of the environmental future and is best described in terms of an adjustment for future expected incomes since environmental benefits are positively related to income levels.

9. Summary of Updated Cost-Benefit Model Parameters

The updated values for the current cost-benefit analysis are summarized in Exhibit V-5, below.

Exhibit V-5 Summary of Parameter Values and Assumptions in Cost-Benefit Model

Parameters	Benchmark Value	Range for Sensitivity Analysis	
		Low	High
Incrementality	1.00	1.00	1.00
GHG Emissions: Value per tonne of CO2	$13.45	$6.75	*$22.40*
Ancillary Environmental Benefits: Value per tonne of CO2	$5.60	$3.40	$11.20
Sales Revenues Probability Parameter (*P1*)	85%	85%	85%
GHG Emissions Reductions Probability Parameter (*P2*)	95%	95%	95%
Social Discount Rate	3.5%	5%	2%
Other Assumptions:			
Duration of Environmental Benefits	30 years	30	30.
Duration of Private Benefits (after follow-on production begins)	30 years	30	30
Economic Rents (% of follow-on Sales Revenues)	5%	5%	5%
Annual Growth Rate of Value of Environmental Benefits	2%	2%.	2%

Note: The variables above and their sources are discussed in detail in the previous section of this report.

G. COST-BENEFIT ANALYSIS FINDINGS

The Fund has provided data on five projects for which applications are on hand. Three of these projects have passed the due diligence review of their Application for Funding, one is being considered by the Board of Directors in November and the last is scheduled for the first quarter of 2013. The data from these projects has been incorporated into the cost-benefit analysis model. These five projects, if fully implemented, would account for all NGBF funding and as such this represents an assessment of the overall NGBF impact. The core finding of the analysis (all results in 2011 Canadian dollars) is that the $500 million NGBF investment will develop five first-of-kind plants that produce total social benefits, net of all costs, of $218 million (sensitivity analysis suggests a range between $91 million and $453 million.) If follow-on plants are added, conservative estimates of the number and productivity of these plants suggest that net benefits will rise to $1.4 billion.

1. Cost-Benefit Findings using Benchmark Scenario

The core results of the cost-benefit analysis, using the available project data and benchmark values (from Exhibit V-5), are summarized in Exhibit V-6 below. This benchmark scenario represents our best estimate of the present discounted value (PDV) of net benefits from each project. Net benefits refer to the social (private plus environmental) benefits less all initial and continuing operating costs. The PDV of net benefits for the total portfolio is simply the sum of these net benefits from all projects included in the analysis. Future values are discounted to the base year, using the social discount rate.

Exhibit V-6 Summary of Benefit-Cost Results

Overall Results-Sales, Environmental Impacts and Total Social Benefits					**($M)**
	Benchmark	High	Low	Follow-on	Benchmark
Discounted totals	TOTAL-5 projects				+ Follow-on
NET PRIVATE BENEFITS	0	0	0	$ 807	$ 807
GHG BENEFITS	$ 208	$ 427	$ 86	$ 392	$ 600
ANCILLARY AIR	$ 10	$ 26	$ 5	$ 19	$ 29
BIODIVERSITY					
TOTAL SOCIAL BENEFITS	$ 218	$ 453	$ 91	$ 1,218	$ 1,436
GHG quantities reduced	19	19	19	37	56
tonnes (M)					
Note: TOTALS-- 30 YEAR HORIZON		**P1=0 .85, P2=0.95**		**For follow-on, P1=0.82, P2=0.95**	

Our overall findings from the available data show that the five project portfolio of NGBF projects generates substantial positive net benefits to society. Funded projects are assumed to generate costs over the development period and during operations while benefits are estimated over a 30-year time horizon from initial production. In the benchmark scenario (column 1), we estimate that the first-of-kind plants will generate total net benefits to society of $218 million in 2011 dollars. In the benchmark scenario, all of these net benefits arise from environmental

benefits, which total $218 million. As noted above, we project no net private benefits due to the higher costs typically associated with first-of-kind plants. Over their projected 30 years of operation, the plants account for a reduction of about 19 MT CO2e in GHG emissions.

The environmental benefit estimates depend on projected GHG emissions reductions and the parameter values that reflect the social cost of a tonne of carbon and the value of related ancillary benefits due to reductions of GHG emissions. The private benefit and cost estimates are based on available project cost data and projections about sales revenue, as well as our assumption about private economic rents. That is, the economic rents are the private benefits. The private costs include actual total project costs (including costs funded by SDTC). Until commissioning is completed, net private benefits are negative (equal to the project costs). Our analysis assumes that only follow-on plants generate positive economic rents, which are above normal returns and are net of all costs. In effect these returns pay back the total investment and then represent above normal returns to investors. These are generated over the 30 year time horizon. New technologies have the potential to earn such above normal returns, and for the cost-benefit analysis we assume the economic rents are equal to 5% of estimated sales revenues for each year after production begins for the follow-on plants.

2. Sensitivity Analysis

An important consideration in evaluating the costs and benefits associated with NGBF projects is the uncertainty surrounding the values of parameters. Uncertainty arises from the wide range of estimates given in the economics literature for the parameters used in the analysis. Finally, there is considerable debate about the appropriate discount rates to use as described in the previous chapter. In the previous chapter we provide a summary of the range of values that we believe to be reasonable for each of the model parameters. These ranges are based on values presented in the published research literature.

We have used the parameter combinations shown in columns 2 and 3 of Exhibit V-5 to calculate the outcomes of the cost-benefit model for these different scenarios (the high and the low which surround the benchmark). The data in columns 2 and 3 of Exhibit V-6 show the results of running the model for the five projects using the high (upper bound) and the lower bound parameter values.

Using this measure, we find that the cost-benefit model results in Net PDV of Total Social Benefits that range from $91 million to $453 million for the five projects reviewed. This is the range of outcomes surrounding the benchmark estimate of $218 million.

3. Follow-On benefits

For follow on plants, the initial plant must be a success. Estimates from the project management literature indicate that for plants reaching the production stage, the P1 for a subsequent plant would be 0.82. This literature includes a presentation by Independent Project Analysis (2010) titled *Commercialization of New Technology*. We attach this P1 to subsequent plants in our analysis. We assume that P2 is unchanged at 0.95. In general, one would expect that subsequent plants will perform better than the first-of-kind for two reasons. They will

follow the typical 'learning curve' for process improvement and cost reduction. They will be scaled to the optimal size whereas the first-of-kind is more likely to have been at the lower end of the commercial size range to keep capital expenditures to an acceptable level for this relatively risky investment. To be conservative in our analysis, we have ignored both of these factors and have used a straight projection from the first-of-kind estimated performance. To explore the impact of follow-on next-generation plants, we have assumed that each first-of-kind plant will generate two follow-on plants, far fewer than the number indicated in the planning documents for the five projects. We further assume that the follow-on will be approved to begin construction after 2 years of operation of the first-of-kind plant, allowing for commissioning and a period of stable operation to confirm the concept and operational results so that conventional debt and equity funding are available. At this stage construction would begin for the two new plants that will be started from each of the projects and they will begin operations one year later. Column 4 of Exhibit V-5 provides our estimate of the impacts of these additional plants.

In estimating follow-on capacity, we have used quite conservative assumptions, which are consistent with our overall methodology. The conservative nature of our assumptions is shown by considering the following points related to future production:

- The ten additional plants will product 682 M liters per year based on total capacity of the first five plants. This would constitute approximately 70% of the estimated incremental Canadian RFS requirements till 2034, assuming that first-generation biofuels would cover initial requirements.
- The operation of 15 plants altogether, as we have assumed, totals 1 B liters per year and is equivalent to the total RFS incremental requirements till 2034.
- Considering that the US is requiring 300 world class biorefineries according to RFS2, the follow-on estimate is very conservative particularly if one assumes that at least one or several technology platforms will be successfully demonstrated through the NGBF deployment and will be further deployed in Canada and/or in the US in order to supply U.S. demand.

Exhibit V-5 shows substantial net benefits from the construction and operation of ten additional plants if the first-of-kind plants are successful. Total social benefits are just over $1.2 billion of which $411 million ($392M+$19M) constitute environmental benefits. The last column of Exhibit V-5 totals the impacts of the first-of-kind and follow-on plants. Total social benefits are approximately $1.4 billion.

4. Discussion and Conclusions

A cost-benefit analysis framework provides a useful tool for assessing the impacts of investments in biofuels such as those funded by the NGBF. The cost-benefit results presented here represent our best estimates for assessing the quantifiable impacts of funded projects.

There are, however, also some important limitations to note:

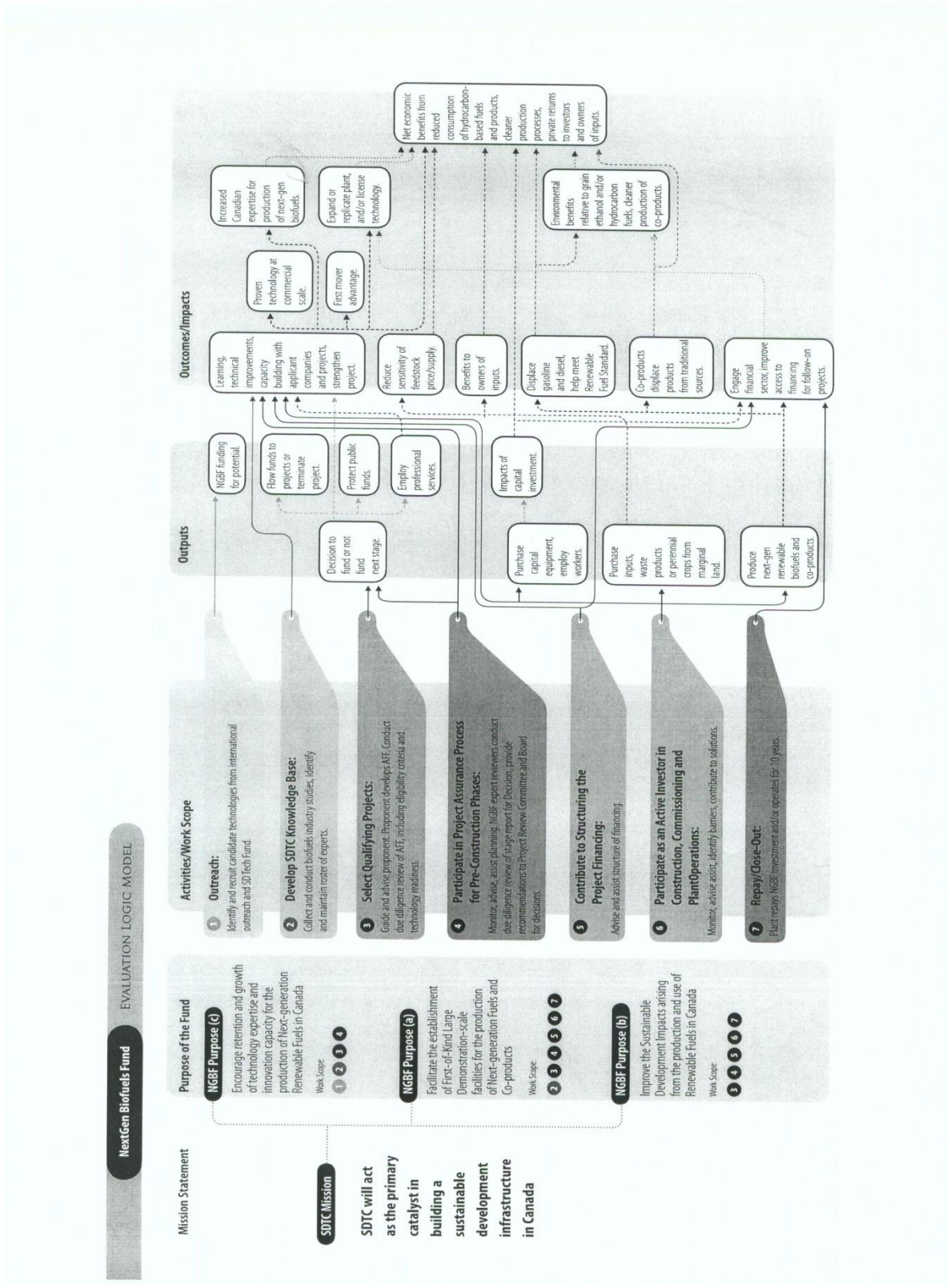
- **Some impacts are not quantified.** We cannot quantify all the potential impacts of the projects assessed. In particular, we do not, at present, have a way to quantify the potential environmental costs related to soil, water and habitat damage that NGBF projects could bring about. This issue is discussed in the literature but, there are no quantitative

estimates of these impacts available. The NGBF Business Case does review these impacts for each project and it appears that impacts are less than for first generation biofuels. The literature referred to considers impacts relative to current fossil fuel production. For projects in which waste material is the biomass source, habitat impacts would likely be negligible.

- **Potential spin-offs not quantified.** We cannot know if one or more of the NGBF-funded projects will produce an enabling technology that will yield large spin-off effects in the future. The potential spin-off benefits of such a possibility are not quantified here.
- **Estimated benefits relate to a baseline year.** The environmental benefits estimated here quantify the economic value of reductions in emissions relative to a baseline that necessarily assumes existing technology. However, in some cases the NGBF-funded projects will displace existing technologies, making environmental improvements by reducing emissions and introducing other quality improvements that are not possible or too costly for to be employed for the existing technology.
- **Technical and economic uncertainties are important.** We have attempted to take these into account by using conservative benchmark estimates and by showing the sensitivity of the results to high and low parameter values chosen to represent reasonable ranges for these parameters.

Given these cautions, our findings indicate that the NGBF-funded projects seem likely to generate significant social benefits over the next decades. There is a high degree of uncertainty inherent in the sales and GHG emission reductions forecasts, so our analysis has used very conservative assumptions. Nevertheless, the results should be treated with some caution. Several forms of sensitivity analysis were performed to attempt to consider alternative scenarios and deal with this uncertainty. Overall, the sensitivity analysis, including the most pessimistic scenario, supports the view that total social benefits outweigh total costs for the projects that we have reviewed.

APPENDIX A PROGRAM LOGIC MODEL FOR THE NGBF



APPENDIX B ECONOMICS OF THE NGBF RATIONALE

Economists generally assume that private markets will promote economic efficiency without government involvement. We observe government intervention and participation in some markets and not others primarily because of perceived market failures. In the economic policy literature, there are a number of reasons why markets may "fail" (fail to lead to the best result). Briefly, the market allocates resources to research and development that are best from the market's point of view. However, market failure means that this market-determined level of resources is not optimal from society's point of view. SDTC and its NGBF is one government mechanism that is intended to correct these perceived problems of market allocation to next-generation.

Canadian capital markets operate within a structure of tax incentives, patent protection and other supporting institutions. Within that structure, normal market processes allocate resources to research and development of new technologies and products based on private investors' estimates of returns on their investments. From the investors' point of view, these processes lead to the appropriate amount of resources being invested in research and development.

From society's point of view, the level of investment in the development and adoption of all types of new technology will be lower than optimal if markets fail to capture all of the effects of these technologies. Economists describe the reasons for this market failure in terms of these components:

- **Incomplete information.** All R&D faces uncertainty about its eventual outcomes (often referred to as incomplete information). Of equal importance, information about potential R&D success may be less clear and available to potential investors than to proponent firms. These two sources of uncertainty cause the market to require a substantial risk premium that lowers the number of projects going forward. From a social perspective, incomplete information leads the market to allocate too few resources to R&D. NGBF grants reduce the extent of the risk that must be borne by the project proponent and the other members of the consortium. SDTC grants reduce the extent of this constraint, or funding gap, for the projects it supports.
- **Public good.** All new technologies suffer from an additional market failure due to spillovers (the public good element of R&D) that prevent investors in new technologies from reaping all of the associated rewards. Those who fund research must pay all the costs of their research and development but other investors (the free riders) may appropriate the R&D results at no cost to them. Certainly tax incentives tend to offset some share of R&D costs and patents or licensing arrangements help the investor to recover some costs from other users of the research results. However, there is ample evidence that these mechanisms are imperfect and that competing firms that do not incur development costs may profit from developments paid for by others. Economists refer to this as the 'public good rationale' for support to all types of R&D.
- **Adoption externality.** The additional technology development externality relates to diffusion, the rate at which new technologies are adopted. The literature indicates that

the costs to firms of adopting new technologies are often a function of the number of other firms that have already adopted. What the literature calls "learning-by-using" means that there is an adoption externality (adoption rates are too slow). Successful NGBF demonstration projects should increase the rate of adoption of those technologies. Ultimately, some of the supported technologies may eventually dominate their markets, displacing competing technologies. In other words, projects may transform their markets when adoption is complete.

In general, the economic literature on support for research and development suggests that government gets better results by providing broad support through market structures, such as tax incentives, rather than picking specific projects or technologies to fund. However, in the case of new technology in the energy-environment area, the rationale for public support of specific technologies is stronger because of the large potential social benefits they can produce. Economists have identified two inter-related reasons for this:

- **Free rider effect.** As indicated above, new inventions and processes in the energy-environment area should improve the quality of life or the well-being of society by reducing air pollution and emissions of GHGs. The economics literature shows clearly that environmental quality is an important determinant of the well-being of Canadians. But society does not pay for these benefits (citizens are free riders). Where such social benefits exist, markets tend to under-invest in research and development related to these technologies and fail to produce the level of investment that is optimal from society's point of view.
- **Negative production externality.** Private investors make production and investment decisions based on the costs that they incur. Yet we know that pollution-related impacts on the environment (e.g. climate change) may have severe negative impacts (social costs) on society. Therefore, technologies that improve environmental quality are particularly attractive in that they are likely to have relatively large social benefits from reducing environmental damage costs. That is, NGBF activities are intended to move the market in the direction of the best use of society's resources. They act to offset the negative production externality that makes social costs of producing output higher than the private cost incurred by producers.

Governments seek to design institutions that can move the market most effectively toward the social optimum. In the area of technology policy, the evaluation literature suggests that those government institutions that work within a market context, funding groups of firms or consortia and having market-oriented elements are most likely to make the largest positive contributions. The structure and focus of NGBF embodies this strategy.

The literature indicates the existence of a series of externality-related factors that, together, provide a powerful rationale for NGBF activities. To establish relevance, it is important that we link these factors to the existing descriptions of NGBF activities and to the evaluation framework. Briefly, these are the relationships:

- **Funding gap.** SDTC's description of its role has featured a discussion of the 'funding gap'. In the SDTC analysis, the funding gap reflects the unwillingness on the part of private investors to accept all of the risks associated with the technology development

and demonstration phase of the innovation process. Clearly, this relates to two factors identified above, the extent to which market forces under-allocate resources to the demonstration phase of energy-environment related technologies due to incomplete information and the private sector's inability to capture the public good element arising from new technologies.

- **Social Benefits.** All of the remaining factors identified by economists, as sketched above, depend upon the performance of the funded technologies in the marketplace. In other words, the evaluation should estimate the impact of SDTC funding on the rate of adoption of the technology, the adoption externality. As the technologies penetrate their markets, benefits in the form of reduced emissions and cleaner air begin to accumulate. These represent the public good that applies to all new technologies and the additional benefits associated with energy and environmental technologies, the free rider effect on consumers and a reduction in the negative production externality that reduces environmental quality.

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