



The NII Innovation Roadmap

NEW THINKING FOR A NEW ENERGY ERA

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The NII Innovation Roadmap

NEW THINKING FOR A NEW ENERGY ERA

The Nuclear Innovation Institute (NII) is an independent, not-for-profit organization that provides a platform for accelerating the pace of innovation in the nuclear industry.

Nuclear energy is a powerful force for decarbonization. It creates good jobs, drives economic growth and produces radioisotopes that are used - among other benefits - for cancer detection and therapies that save lives in Canada and around the world. The Institute is founded on the belief that the industry can enhance these vital contributions by adopting a structured approach to fostering innovation.

NII's goal is to shape a Canadian nuclear industry that embraces new thinking, new technologies and new lines of business that play a central role in the global shift to a low-carbon future.



I. Why Nuclear?

The world is entering a new energy age.

Reliable, affordable energy is the oxygen of human development. And for more than two centuries, we have burned fossil fuels to harness the power required for the vast prosperity and comforts of our modern world. Fossil fuels powered the rise of mass manufacturing, enabled new kinds of ever-faster transportation, led to exponentially greater food production and a host of products – and expectations – that are now deeply embedded in modern life.

But extracting and burning energy sources that had lain dormant for millions of years came with a cost: a rapid, dangerous rise in the release of heat-trapping gases like carbon dioxide, methane and nitrous oxide into the earth’s atmosphere. By intensifying the earth’s natural “greenhouse” effect we are dramatically altering the climate systems that sustain human life and modern societies.

Unfortunately, the urgency for deep cuts in carbon emissions clashes with our thirst for accessible, affordable power. Global energy demand continues to rise, putting the world on a trajectory that increases the likelihood we will face damaging effects from climate change. It has also launched a frantic search for low-carbon ways to power our homes, business, cars, farms and more that would allow us to shift to a future where net carbon emissions reach zero.

Some of that demand may be met by massively ramping up the supply of energy we get from renewable sources like solar and wind power, or by achieving breakthroughs in still-developing technologies like long-term battery storage or hydrogen. But until these alternatives prove capable of powering 21st century societies with concentrated, cheap and efficient energy, the world will most likely continue to burn more coal, oil and gas.

Solving this decarbonization challenge is perhaps the greatest test of our generation.



That's why nuclear power plays an indispensable role in the world's energy future. It is a proven energy source, generating consistent power at the scale and concentration demanded by an urbanizing world. It is a clean source of power, emitting none of the greenhouse gases that heat the planet. It is safe. And the energy intensity of the fission process - splitting uranium atoms in a reactor to produce electricity - means nuclear energy puts a low demand on land use.

Furthermore, 20th century scientists discovered that by-products of nuclear fission can be used to detect and treat cancerous tumors – along with other benefits to public health. These artificially produced radioisotopes are used to treat some forms of cancer and to sterilize surgical instruments, kill bacteria in our food supply, monitor water quality, fight contagious diseases spread by insects, and detect leaks or dangerous weaknesses in buildings and industrial equipment.

These peaceful applications of nuclear energy carry hope that a cleaner, healthier planet is within reach, ensuring the greater equality in access to energy that can protect the achievements of our modern world and lay the foundation for an even-better future.



II. Nuclear's Innovation Challenge

The nuclear industry is at an inflection point. An increasing number of countries, cities and companies are committing to reach net-zero carbon emissions by 2050, drastically reducing human-generated emissions and removing the remaining carbon from the atmosphere. And getting Canada to a state of net-zero requires a significant role for nuclear in the energy mix.

The industry must seize this opportunity. But despite the crucial part it plays in net-zero scenarios, the nuclear industry contends with persistent frictions that hamper its long-term viability.

They are:

- **Costs:** While the price of nuclear-generated electricity remains low, the costs related to reactor refurbishment along with projected medium-term price increases in nuclear-sourced electricity risk narrowing the industry's advantage over renewables and other competitors.
- **Reputation:** Disproportionate perceptions about the risks associated with nuclear power remain stubbornly present in the public mind.
- **Legacy habits:** Sluggish adoption of digital and emerging technologies has left the Canadian nuclear industry under-equipped to compete for a share of the demand for next generation energy technologies in global markets.

The nuclear industry must address these vulnerabilities. To help meet the challenge, the Nuclear Innovation Institute is committed to supporting projects and activities that enhance the competitiveness of nuclear power in the journey to decarbonization. All NII projects and activities must meet the test of showing how they will contribute to improving industry performance.



The path to success runs through developing a culture of greater innovation. If nuclear is to rise to meet its challenge, it must:

- Increase its pace of adoption and implementation of solutions that radically cut costs and improve performance;
- Find ways for new technologies and platforms to improve efficiencies in electricity production and delivery, and to enhance worker and public safety;
- Collaborate with and learn from other sectors about gains derived from the implementation of emerging technologies and platforms;
- Find ways to further reduce the environmental impact of operations and infrastructure through the full lifecycle, from source to end use and decommissioning;
- Find new applications in medicine and public health for the radioisotopes that are already integral to many cancer treatments, thereby seamlessly embedding the nuclear industry as an essential part of people's lives.

Making innovation a core competency in the Canadian nuclear industry is key to meeting these demands. Innovation is a disciplined process that requires frameworks to foster that new thinking, drive development of those ideas and ultimately turn them into value. The Nuclear Innovation Institute was established to support its members and the wider industry as they travel that path.

NII will help its members identify opportunities for innovation, select those with the best opportunities for success and path to implementation, provide a platform for experimentation and collaboration in testing potential solutions, and share lessons learned. This project guide brings structure to that process.

Like well-conducted innovation, the process itself is open to iteration, improvements and pivots. It is a starting point. But NII's commitment to achieving results through continuous innovation will help propel the nuclear industry into this new energy age.



III. NII Principles

All NII projects and activities will be judged on their potential contribution to nuclear's ability to play a major role in the shift to a low-carbon economy.

To meet that test, NII's innovation pathway is based on four principles:

- 1. A nimble, business-relevant project approach.** NII's project process is designed to deliver value early and often by finding solutions quickly – or failing fast. We are committed to speeding up the pace of innovation in nuclear, working to radically lower costs and making the industry fit to compete with other energy sources.
- 2. Focus on demand-driven, high-impact solutions that have a path to implementation and adoption.** Our projects are demand-driven, leaning towards real-world adoption, implementation and commercialization. NII projects are weighted towards effective solutions with a high prospect of adoption.
- 3. A preference for addressing horizontal challenges in the industry.** NII looks to solve problems and make improvements that benefit the whole industry and its ecosystem, not just a single company (though it will still undertake projects with a single company). By raising awareness of new technologies and ideas, NII can trigger ideas for projects that improve the competitive performance of the entire industry.
- 4. Leverage the strengths of our members for global leadership.** NII work should focus on enhancing the globally competitive advantages of our member companies and the Canadian nuclear supply chain.



IV. A Guide to the NII Application Process

GENERAL RULES

To improve the competitiveness of nuclear power generation in decarbonizing the global economy, NII projects will run projects that bring new expertise and technologies to the full fuel generation cycle. Our projects are designed to move quickly, share risk, allow for experimentation, and help participants understand failure when it happens– all in a neutral environment.

NII practices continuous improvement and this process may iterate according to conditions. The current version is designed for projects to deliver quick wins that can demonstrate the value of innovating.

1. Criteria

- Every NII project proposal should demonstrate how it will contribute to improving the long-term viability of the nuclear industry as a force for decarbonization.
- NII projects come largely from two sources:
 - a) **From Members**, seeking solutions to problems that they have identified as priorities;
 - b) From innovative ideas **proposed by NII** that could be of value to Members.
- Projects can focus on any area of the business that is a priority to Member(s), including, but not limited to: new technologies and processes that lead to operational improvements, the digitization of processes, enhanced cybersecurity, improvements to the materials and operations of energy production, production of new and existing medical isotopes, greater environmental sustainability, cost reductions, improved workplace conditions and safety, enhancement of workforce skills and knowledge or wider social benefits.
- NII seeks and defaults to projects that meet our four principles, with particular emphasis on those that have a high likelihood of implementation and an impact on radically reducing costs. NII is less inclined to support projects that propose routine or incremental changes to existing practices, even if those would lead to improvements.



- NII projects can drive or be part of “complete solutions” to problems, incorporating systems change, skills development, etc, not simply the adoption of technologies.
- Projects can take many forms: feasibility studies, business cases, proof of concept, demonstrations or prototypes, the creation of digital twins, and more. They can lead to systems improvement (greater efficiencies, lower costs), safety improvements, new intellectual property or business lines, environmental improvements (lower water usage, lower GHG emissions in infrastructure, thermal controls, etc...), workforce skills development and more.
- NII will consider project proposals at all stages of development but favours those that are closer to adoption and implementation.
- NII welcomes projects whose outcomes can have applications outside the nuclear industry.

2. Who can participate in projects

- **Founding Members** can propose projects either on their own or in partnership with other Founding Members. Outside entities, such as service or tech providers, can participate in projects if invited by a Founding Member.
- **External companies and organizations** which provide services, technologies or other assets to a project are not required to be members of NII to participate but engage only at the invitation of a Member. This encourages projects to connect with the highest quality service or technology providers as they build their innovation teams.
- **Eligible external participants** in NII projects include, but are not limited to:
 - companies based in Canada
 - industry associations
 - technology providers
 - private and public R&D labs
 - university and college researchers
 - municipalities
 - indigenous communities



- individuals
- incubators
- institutes
- government agencies and programs

3. The Role of NII

- NII's engagement is led by the Chief Innovation Officer (CINO).
- NII is a **neutral** facilitator of projects. NII holds no commercial interest in any project unless otherwise negotiated as part of a Project Charter.
- ***Through the leadership of the CINO, NII's role in projects is to:***
 - facilitate the generation of project ideas;
 - assist project leads in shaping ideas, goals and scope; run the external assessment process;
 - assist the project leads in identifying and filling gaps in capabilities for their project;
 - assist the project participants in building the innovation team;
 - seek and help secure external sources of funding for a project, if required;
 - facilitate a Project Charter agreement between all parties on their roles and responsibilities within the project;
 - provide the physical space for the project and IT infrastructure. If required;
 - administer the financial controls of each project (paying invoices, submitting claims for external funding);
 - ensure that project execution remains compliant to the Project Charter (meeting deadlines, etc...); and
 - amplify project outcomes.



- NII may invest in and provide supporting technologies or software for projects;
- NII may charge a fee for service based on the overall value of the project. Any fees would be negotiated and agreed with project participants.

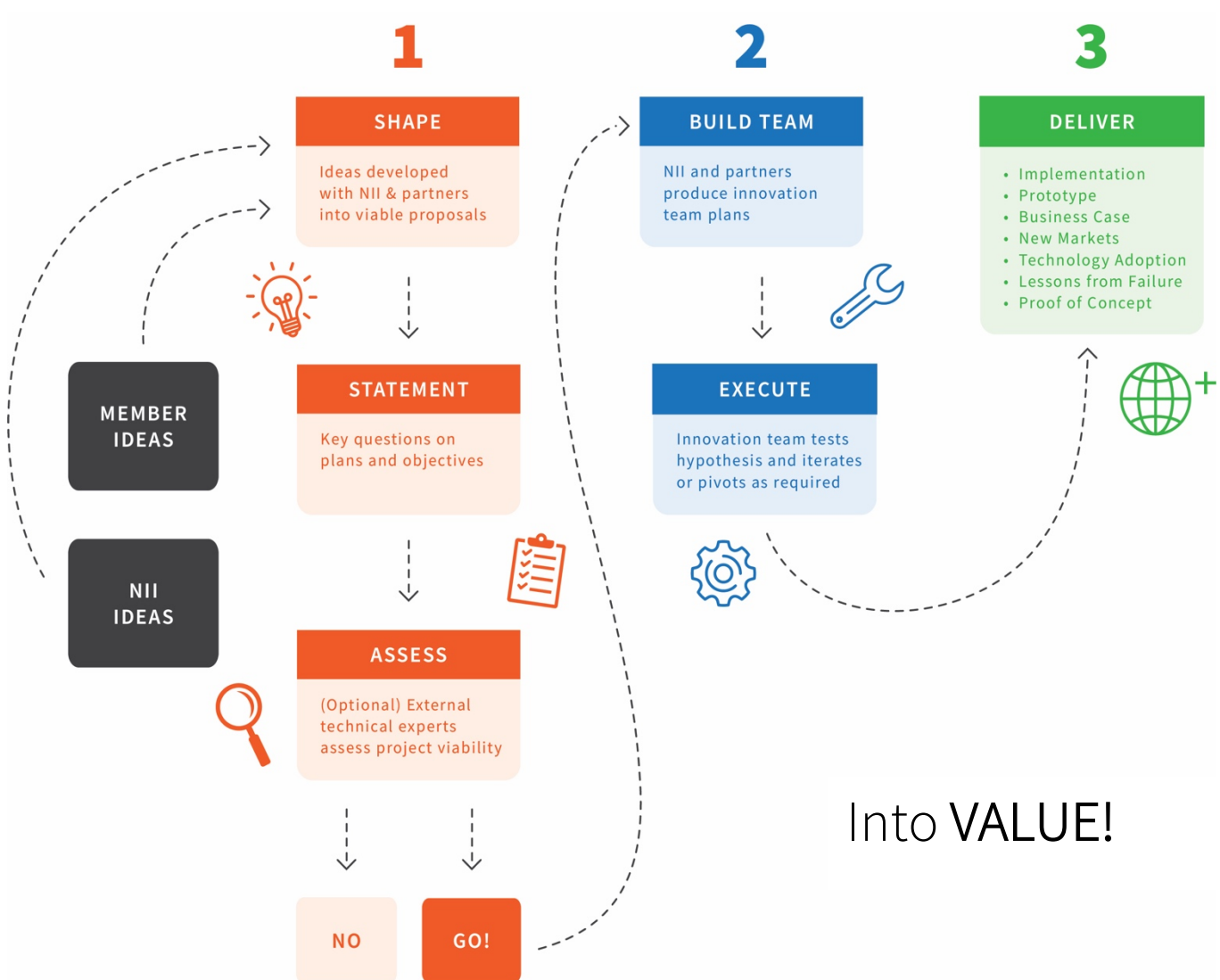
4. Project Length

- NII's focus on moving fast encourages proposals for projects of shorter durations. Execution time for a project can run as quickly as a few weeks, though NII will support projects that run as long as three years. All projects should be of a known and finite duration.
- Longer projects can be broken into stages to allow for recalibration or reassessment along the path.
- Project participants must continue to assist the NII in monitoring the results of their project for an agreed-upon length of time following its completion in order to more fully measure its impact.



V. NII Innovation Roadmap

Turning IDEAS...



Stage 1

IDEAS

NII projects start with ideas. This stage is intended to assess and shape those ideas before proceeding to the application stage. All parties will sign a **Non-Disclosure Agreement** before discussing project details.

Projects enter the NII project funnel from two sources:

1. Founding Member Idea Generation

Projects can be proposed and led by a Founding Member organization, or brought by an outside organization that has a Founding Member as a partner or sponsor.

These projects will have been generated by internal activities (customer feedback, technology shifts, creative thinking, cost imperatives, etc. . .) that identified a specific, business-worthy need or challenge or an area of opportunity that requires an innovative solution. The idea will have been ranked as a priority internally and have support within the business for implementation.

The project proposal will have arisen from the organization assessing a wide variety of potential solutions and arriving at an actionable problem statement to test a hypothesis. This stage can include collaboration with the NII's Chief Innovation Officer (CINO) to evaluate whether the opportunity fits within the NII's scope.



2. NII Idea Generation

NII will continually explore and cultivate innovation opportunities through workshops, hackathons, new technology showcases, brainstorming and challenges.

This creative form of ideation seeks to leverage opportunities from trends in technology, from changes in the nuclear industry markets, from new developments in the policy environment, or from notable advances in other sectors.

Projects can emerge from NII open challenges, or be brought forward by Founding Members or external entities in conjunction with NII. Proposals may first require an agreed-upon design sprint to test its viability before moving to the project application stage.



Stage 2

SHAPE

NII works with a designated Project Lead on each project to shape the idea into a problem statement and a project application.

NII's CINO assists the participants in shaping the proposal to:

- ensure it is in scope and has a plausible path to implementation;
- break the project into several smaller projects to allow for assessment, iteration and pivots if necessary;
- improve detail and focus of the proposal;
- discuss the need and likelihood of other funding sources;
- discuss the need for and other potential partners

PROJECT STATEMENT

Once the participants have decided on the project problem, NII will facilitate the creation of a Project Statement that responds to key questions about the nature of the project. The Statement will be authored by the Project Lead, and broadly address:

- its degree of innovation (is it truly new or has it been tried elsewhere?);
- its market or cost-saving potential and whether it offers a global competitive advantage to the Canadian nuclear industry;
- its business case;
- it's likelihood of real-world implementation, including identification of obstacles to operationalization and scale-up;



- whether it demonstrates the application of a new technology in nuclear or a clear improvement in technology use;
 - the potential social or environmental benefits of the project, whether in the region or beyond;
 - its contribution to workforce improvement and promotion of innovation for the organization and the industry;
 - its identification of risks and risk-mitigation.
- There is no defined length for a Statement, but they should not generally be longer than six (6) pages (8.5" x 11", double-spaced), in 12-point font.



Project Statement – The following questions are a guide to creating a Statement.

1 *Describe your idea and clearly show how it is innovative for one (or more) of NII's three areas of focus.*

- *The challenge, the motivation, the objectives.*
- *What's the current state-of-the-art in this area?*
- *How does it push the current boundaries in the industry or field?*
- *What is the degree of difficulty in implementing the solution in the real world?*
- *What is the project's level of development (feasibility study, minimum viable product/prototype, ready to move into production or commercialization)?*
- *What are the deliverables? (feasibility study; proof of concept; demonstration; modeling; implementation; development of new technology; application of a new technology outside nuclear; etc...)*

2. *Describe how this project would benefit the nuclear industry or the field in which it applies (environmental sustainability, nuclear medicine, etc...).*

- *How will the project save costs?*
- *How does it improve the nuclear process or field in which it applies?*
- *Does it give the Canadian nuclear industry a global advantage?*
- *What is the business case or expected economic benefit?*
- *Does it open a new market opportunity?*
- *Could it lead to a spin-off company or division?*
- *Does the project offer potential social benefits (safety, environmental, health, new skills for workers)?*
- *Does it improve the skills and capabilities of the workforce?*
- *Is it scalable or does it serve as a model for the rest of the industry?*
- *Does it improve the supply chain?*



3. What is the likelihood that the solution/technology/process can be implemented in the real world?

- *How will the hypothesis/technology/process solution be tested?*
- *What are the obstacles to adoption?*
- *Are they surmountable and how?*
- *Can it be applied within the existing regulatory framework?*
- *How do you plan to mitigate risks against adoption and scale up?*

4. Has this solution or something similar been tried/implemented elsewhere in the world?

- *Is it net new to the industry?*
- *To Canada?*
- *To your company?*
- *Does the project apply technologies already in use in the industry or would it introduce new technologies to nuclear?*
- *Why is this technology/process/solution better than other, existing ones?*

5. What are the project's anticipated costs?

- *Breakdown the project cost by estimated spending on:*
 - *Labour*
 - *Technology*
 - *Software*
 - *Machinery and equipment*
 - *Licensing*
- *Will the project use subcontractors?*
- *Does the project require external funding?*
- *Is there an investment opportunity?*



6. Describe the make-up of the innovation team.

- *List all project participants, their role, and identify any gaps in capabilities (skills, software, technologies, assets, etc...) that need to be filled from outside the participant group.*
- *Who will manage the project?*
- *What is the innovation team's experience (previous projects in similar areas, years of experience, etc...)?*
- *Do the partners have the ability, skills and experience to manage the project themselves?*
- *Do the partners already have a breakdown of roles and responsibilities of participants?*
- *What additional skills does the project team require?*
- *What additional assets does the project team require?*

7. How long is the project expected to last and identify the major milestones?

8. How will outcomes be measured for success?

Project Statements can include an additional two (2) pages of charts, graphs or images if desired.



“GO” or “NO-GO” - A Review by Expert Advisor Group (if desired)

Where appropriate and with the consent of all parties, NII may seek an external assessment of either the full project application, or part of it, such as the viability of using a proposed technology in a particular application. The review will be conducted by relevant experts known as the Expert Advisory Group. This step can provide valuable feedback to the Members on the merits of their proposal, such as identifying gaps or oversights, before the parties commit to further spending.

The Expert Advisors provide advice only. The decision to approve or reject projects rests with NII and Project Participants. Not every project requires a review.

The Expert Advisors will provide NII management and project partners with the area expertise in technical, commercial and strategic questions that improve the assessment of project proposals.

- No Expert Advisor will be permitted to engage with or review any project in which they have a conflict of interest. Expert Advisers will sign a Non-Conflict Agreement and a Non-Disclosure Agreement with NII and the Project Partners before reviewing each project.
- Expert Advisory Panels are staffed by consent of Project Participants. Founding Members are not required to accept an Expert Adviser on a panel that is reviewing one of its projects.
- Expert Advisors will bring appropriate capabilities from such specializations as nuclear engineering, nuclear science, data science, data analytics, software, technology specialization (robotics, machine vision, additive manufacturing, etc...), new platforms (artificial intelligence, machine learning), materials, business development, regulatory affairs, medical isotopes and more.
- Expert Advisors will be recruited by NII’s CINO from the nuclear industry (including both retired and active industry personnel) as well as other sectors relevant to the project (for example, advanced manufacturing). They will also include academics, business leaders and consultants with relevant experience and knowledge of nuclear processes.
- Experts may be recruited specifically for a project when assessment requires particular specialization or expertise or be part of a standing resource.



- Projects can be reviewed by Panels of anywhere from 1 to 3 Expert Advisers depending on the cost and complexity of the project.
- NII's CIO is primarily responsible for identifying the Expert Advisors to the Panel for each review.
- Expert Advisors may ask the Project Leads to provide more detail or clarity on their answers.
- The Panel will recommend either "Go" or "No Go" to the NII on each project based on the majority of votes.
- Project proposals recommended a "No Go" may return to the Project Participants for reconsideration, a rewrite and resubmission.
- Project proposals given a "Go" proceed to NII management to move to the Project Charter stage.



Stage 3

BUILD TEAM

Innovation Team Formation

Once an application is approved as a project, the participants will come together under the independent auspices of NII's CINO to design the innovation team. NII will help the partners fill any capability gaps by:

- seeking outside funding
- recruiting outside expertise
- finding appropriate technology providers
- finding appropriate business support

Project Charter (including Intellectual Property protection)

NII's CINO will assist the partners and other parties in negotiating, agreeing and signing a Project Charter that will be the legal basis of the project. NII will help the partners decide on:

- roles and responsibilities of each party (who leads and is responsible for compliance, reporting, etc...)
- project deliverables
- work plans
- timelines
- cost-sharing
- legal protection of background IP ownership
- agreement on how to share any IP developed during the project
- agreement on liability for any outside funding

The final understanding will be codified in a Project Charter based on an NII template and customized to reflect the unique characteristics of each project.



Intellectual Property Protection

Protecting the intellectual property (IP) of all project participants is essential to a successful project process. Project Charters will ensure that all parties can participate with assurance that any IP they bring to a project will be fully protected.

Every Project Charter will include clear and binding IP provisions tailored to the specific conditions of that project. NII will provide an IP Agreement template that all project participants can amend or re-draft to arrive at agreement on how IP will be managed.

NII projects adhere to two broad principles:

1. Ownership of all background IP brought to a project remains the sole property of its owner, whether a Founding Member or external entity (a technology provider, for example), unless otherwise agreed by the owner; and
2. An agreement will be included in the Project Charter on how parties will share, license or manage any IP developed as part of that project.

EXECUTE Project Work and Monitoring

Pivots based on discoveries, changing features or technology performance are part of the innovation process. NII understands the need for - and the value of - critical assessment in mid-stream and encourages pivots where appropriate. The innovation teams are required to keep NII informed of material changes to the project.

- The parties will run their project and report on their progress to NII's CINO as required by the Project Charter.
- Deviations in compliance with the Charter must be reported within 30 days to NII.
- NII may request a status update from the Project Lead at any time.
- Partners should make every effort to resolve any disputes but should conflicts remain unresolved, NII will mediate between the parties.



Stage 4

DELIVER

Outcomes and Reporting

- All project outcomes must be shared with NII.
- Project participants must continue to measure the results of their project for an agreed-upon length following its completion in order to fully measure its impact.
- Publication and promotion of findings to the industry and public must acknowledge NII's role and include NII branding on any materials arising from the project.
- NII will join or lead in publicly promoting the project outcomes if the parties wish.

THE NII INNOVATION PATHWAY:

CREATIVE.

NIMBLE.

DRIVING VALUE.

NEW THINKING FOR A NEW ENERGY ERA

This document is for guidance only. NII reserves the right to adjust or amend the process as it requires.

