



# The NII Innovation Roadmap

**NEW THINKING FOR A NEW NUCLEAR ERA**

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# The NII Innovation Roadmap

## NEW THINKING FOR A NEW NUCLEAR 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?

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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 is expected to double by the middle of this century, putting the world on a trajectory that increases the likelihood of the most damaging effects of climate change. It has also launched a frantic search for alternate, lower carbon ways to produce electricity and power.

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 fuels. 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 time.

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 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.

In this century, we continue to unlock new medical and environmental uses for radioisotopes, a reminder that the nuclear industry is essential to a cleaner, healthier planet.

## II. Nuclear's Innovation Challenge

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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:** Perceptions about the dangers of radioactive waste and the risk of catastrophic failure remain stubbornly present in the public mind.
- **Legacy habits:** Sluggish adoption of digital and other new technologies has left Canadian nuclear under-equipped to fight for a share of the rising demand in new 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 its challenge, it must:

- Increase its pace of adoption and implementation of new 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 disruptive 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 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, 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

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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. By raising awareness of new technologies and ideas, NII can trigger projects that improve the performance of the entire industry as it competes with other energy sources.
- 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. Areas of Innovation Focus

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NII has identified three initial areas of strategic focus for its projects:

1. **Energy Transformation** - Enhancing the competitive advantages of nuclear through demonstration and adoption of new technologies and knowledge, process optimization, risk reduction and the development of new businesses and markets.
2. **Nuclear Medicine and Public Health** - Accelerating research and advocacy for improved cancer treatments, as well as expanding the environmental, agricultural and industrial applications of radioisotopes.
3. **Environmental Sustainability** - Promoting action that improves the health of our water, land and air and deals with the challenges of the full fuel cycle, from extraction of raw materials to waste management.

## V. A Guide to the NII Application Process

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### 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 respond to industry demand for improvement in our three broad areas of focus: energy transformation, nuclear medicine and public health, and environmental sustainability. In exceptional cases, NII will consider engaging in projects outside that scope.
- 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 look to 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. Priority areas for projects that are further from readiness for implementation will be published on the NII website.
- 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, in partnership with other Founding Members, with General Members, or with external entities. Once a project is approved, any external entities must become General Members of the NII.
- **Outside entities** can propose and participate in projects to NII. Founding Members have the option of partnering in or sponsoring projects brought forward by an outside entity. Outside entities whose projects are approved by NII must become General Members of NII.
- **External companies and organizations** which provide services, technologies or other assets to a project are not required to be members of NII to participate. This encourages projects to connect with the highest quality service and 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. It takes no commercial interest or stake in any project.
- **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;

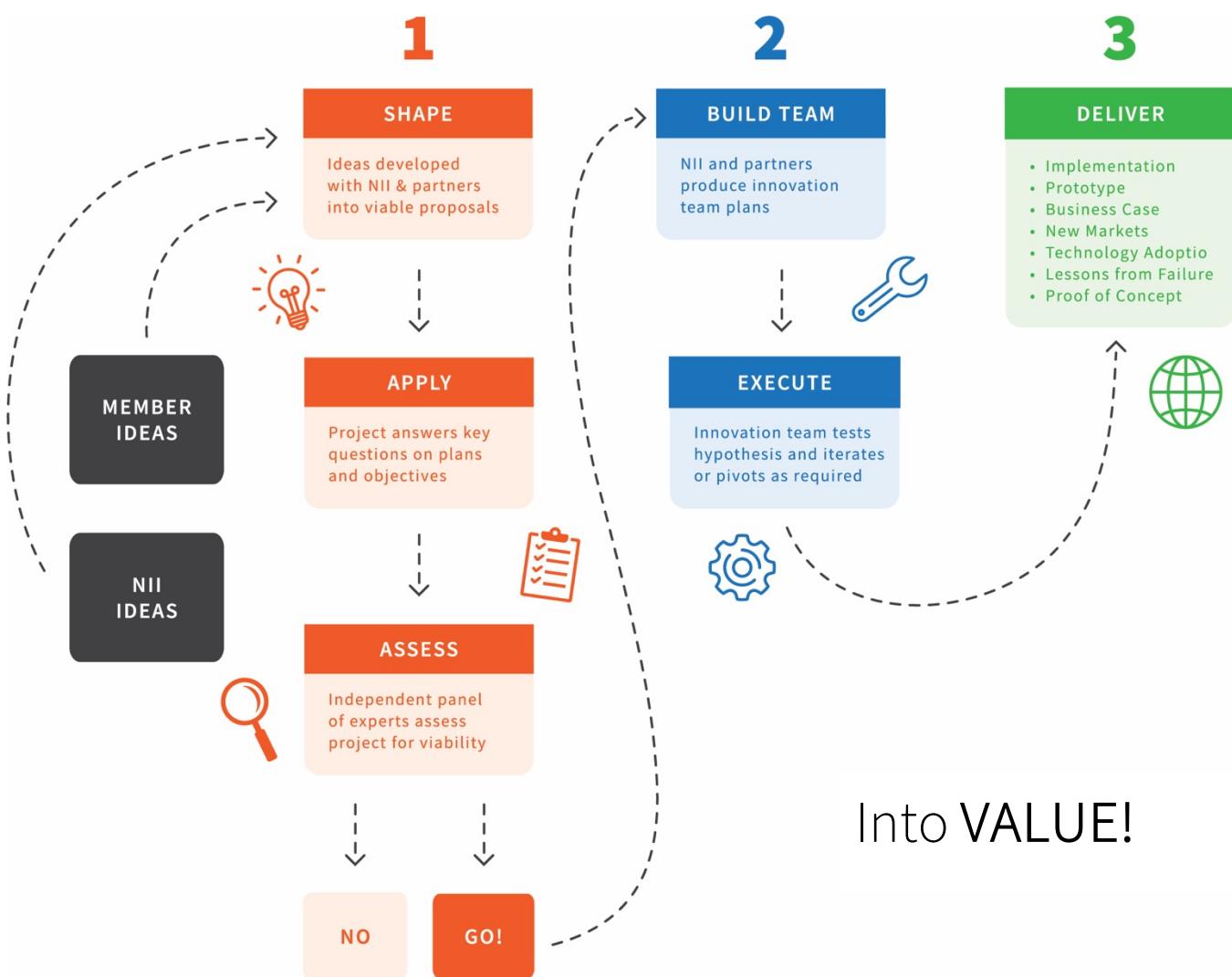
- facilitate a Project Charter agreement between all parties on their roles and responsibilities within the project;
  - provide the physical space for the project and IT infrastructure. If required;
  - administer the financial controls of each project (paying invoices, submitting claims for external 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, as negotiated with the 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.

## VI. The 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 an initial 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 from an outside organization that has a Founding Member as a partner or sponsor (outside project leads must become General Members of the NII once their project is accepted).

These projects will have been generated by internal activities (customer feedback, technology shifts, creative thinking, costs 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 for implementation in the business.

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 project leaders to shape their idea into a problem statement and a project application.

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

- ensure it is indeed 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

### **APPLY**

Once the participants decide to proceed to a formal application, the Project Lead must submit a Project Application to NII.

- The Application will be evaluated on the quality of the proposal's content and presentation.
- Broadly, the Application will be judged on:
  - 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;
  - its 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.
- The Application should be no more than six (6) pages (8.5" x 11", double-spaced), in 12-point font.

## **Project Application Questions**

**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?**

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

## **“GO” or “NO-GO” - A Review by Expert Advisor Group**

Before being approved, the proposed project’s application will be reviewed and judged by relevant experts in the field known as the Expert Advisory Group.

The Group will provide NII management with the technical, commercial and strategic experience and expertise to judge (and improve) project proposals, as well as the likelihood of implementation in nuclear power generation.

- 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.
- All members of the Group will sign an NDA before reviewing any project.
- **Founding Members** of the NII will be eligible to propose one (1) senior employee to the Expert Advisory Group.
- 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 with NII before reviewing each project.
- Applications will be reviewed by Panels of 3 or 5 Expert Advisers depending on the cost and complexity of the project (as determined by the NII).



- NII's CIO will assign the Expert Advisors to the Panel for each review.
- Expert Advisors may ask the project proposal 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 given a “No Go” may go back to reconsider, rewrite and resubmit.
- Project proposals given a “Go” proceed to NII management for formal approval to move to the Project Charter stage.

## **Stage 3**

### **BUILD TEAM**

#### **Innovation Team Formation and Project Charter**

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. The CINO will assist the partners and other parties to create the innovation team as well as negotiate, agree and sign a Project Charter that will be the legal basis of the project.

- NII will help the partners fill any capability gaps by:
  - seeking outside funding
  - recruiting outside expertise
  - finding appropriate technology providers
  - finding appropriate business support
- NII or its delegated party 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.

## **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 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 (1 - 5 years) following its completion in order to more fully measure its impact.
- Publication and promotion of findings to the industry and public must acknowledge the NII 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 NUCLEAR ERA**

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