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# NIA Project Registration and PEA Document

### Date of Submission

Oct 2026

### Project Reference Number

NIA3_NGET0021

## Project Registration

### Project Title

GPU-based EMT Simulator

### Project Reference Number

NIA3_NGET0021

### Project Licensee(s)

National Grid Electricity Transmission

### Project Start

December 2026

### Project Duration

2 years and 0 months

### Nominated Project Contact(s)

Jonathan Hunte (Box.NG.ETInnovation@nationalgrid.com)

### Project Budget

£843,000.00

### Summary

With the rapid growth of inverter-based resource (IBR) and increasing power-electronics-driven system dynamics, EMT-level detail is increasingly required for dynamic studies involving connection applications, wide-area disturbances, and operational decision support. However, traditional electromagnetic transient (EMT) simulations are computationally intensive, which impose constraints on model fidelity and the number of scenarios that can be simulated. This project will advance and validate a GPU-accelerated EMT simulation capability, enabling significantly faster and more scalable EMT studies while maintaining high numerical fidelity. This will provide a significant increase in EMT simulation speed, allowing more complex simulations and more scenarios to be performed, ultimately leading to more informed, less conservative reinforcement decisions.

### Third Party Collaborators

Hylectra Limited

### Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

### Problem Being Solved

The electricity transmission system is undergoing a fundamental transition as increasing volumes of inverter-based resources (IBRs), such as offshore wind farms, solar generation, battery energy storage systems (BESS), High Voltage Direct Current (HVDC) assets, STATCOMs, and other power-electronics-based technologies, replace or supplement traditional synchronous generation. Unlike conventional power stations, these technologies introduce fast electromagnetic and control-system dynamics that can occur over microsecond to millisecond timescales and are not always captured adequately by traditional RMS (phasor-domain) simulation tools.

To understand and manage these emerging behaviours, transmission operators, system planners, and connection customers are increasingly reliant on electromagnetic transient (EMT) simulation studies. EMT simulations model instantaneous voltages and currents in the network and can accurately represent converter switching behaviour, inverter control systems, protection systems, harmonics, fault response, control interactions, and other high frequency phenomena. EMT studies are now routinely required to support connection applications, assess wide-area disturbances, validate the performance of HVDC and FACTS devices, evaluate grid-forming technologies, and ensure network stability in low-inertia operating conditions.

While EMT modelling provides the required level of fidelity, it creates a significant computational challenge. EMT simulations typically operate with time-steps in the microsecond range, requiring tens of thousands of solution steps to simulate a single second of system behaviour. Modern EMT models may also include large transmission networks, detailed converter representations, protection systems, harmonic filters, and frequency-dependent transmission line models. As a result, simulation runtimes can extend to many hours or even days depending on model size and study complexity.

This computational burden is becoming increasingly problematic as the number and complexity of studies continue to grow. Every major inverter-based connection project may require hundreds of EMT simulations covering different fault types, operating conditions, dispatch patterns, equipment outages, control settings, and future network configurations. Engineers often need to assess many scenarios to gain confidence that a new project will remain stable under a wide range of operating conditions. However, long simulation runtimes frequently force compromises in study scope, including reducing model detail, limiting the number of scenarios assessed, simplifying network representations, or applying conservative engineering assumptions.

Most existing EMT software platforms were originally developed for CPU architectures. Although highly accurate, these architectures offer limited parallel processing capability and are not ideally suited to the highly repetitive mathematical calculations required in EMT simulation. Each simulation time-step requires large numbers of device calculations, control-system evaluations, state updates, network matrix assembly operations, and matrix solutions. As models continue to grow in size and complexity, these calculations become a major bottleneck that limits simulation performance and scalability.

The proposed project addresses this limitation by advancing and validating a GPU-accelerated EMT simulation capability. Modern Graphics Processing Units (GPUs) contain thousands of processing cores capable of executing many calculations simultaneously. Many EMT simulation tasks, including converter calculations, control system evaluations, network solution processes, and device state updates, are highly parallel in nature and are therefore well suited to GPU execution. By exploiting massively parallel GPU computing, it becomes possible to significantly increase simulation performance while maintaining the numerical fidelity required for power system studies.

## Method(s)

The project will advance and validate GPU-accelerated EMT simulation capability for representative electricity transmission applications. The approach will focus on demonstrating that GPU-based computation can provide significant improvements in EMT simulation performance while maintaining the numerical fidelity required for power-system studies.

A representative transmission-system benchmark model and dynamic study scenarios will be used to assess simulation accuracy, computational performance and scalability. Results from the GPU-based simulation environment will be compared with established EMT simulation outputs using relevant electrical quantities and transient responses.

The project will also assess interoperability with existing EMT modelling workflows. This will include validating approaches that enable a supported existing EMT model to be used within the GPU-based simulation environment, reducing the need for users to reconstruct models manually. The resulting capability will be assessed through a representative model, with performance, validation outcomes, practical limitations and future deployment considerations documented.

**Data Quality Statement (DQS):**

The project will be delivered under the NIA framework in line with OFGEM, ENA and NGGT / NGET internal policy. Data produced as

part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal Sharepoint platform ensuring access control, backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

**Measurement Quality Statement (MQS):**

The methodology used in this project will be subject to our supplier's own quality assurance regime. Quality assurance processes and the source of data, measurement processes and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and will be made available for review.

In line with the ENA's ENIP document, the risk rating is scored low.

TRL Steps = 2 (3 TRL steps)

Cost =2 (£500,000 - £1m)

Suppliers = 1 (1 direct supplier – Hylectra Only)

Data Assumption = 1 (Defined assumptions & principles)

Total risk score = 2+2+1+1 = 6

Overall risk rating = Low.

## Scope

The project is a 24-month innovation project focused on advancing and validating GPU-accelerated electromagnetic transient simulation for electricity transmission applications. The project will assess numerical fidelity, computational performance, scalability and practical interoperability with existing EMT modelling workflows.

The project is structured into four technical Work Packages:

**WP1 – GPU-Based Simulation Framework Design and Core Development**

This WP will advance and validate the GPU-based EMT simulation capability required for representative transmission-system studies. The work will establish the simulation functionality needed for project validation and assess its computational performance and scalability.
Deliverable: Prototype GPU-based EMT simulation capability and profiling baseline.

**WP2 – Model Development and PSCAD Benchmark Case Setup**

This WP will establish representative EMT benchmark systems in both PSCAD and the GPU-based simulation environment. Equivalent study cases and dynamic scenarios will be prepared to provide a consistent basis for subsequent comparison and validation.
Deliverable: Dynamic-scenario suite and PSCAD reference benchmarking.

**WP3 – Validation, Performance Benchmarking and Tuning**

This WP will assess the numerical fidelity and computational performance of the GPU-based simulation capability against other CPU-based EMT tool using the agreed benchmark cases. The work will evaluate transient behaviour, numerical consistency, simulation runtime and scalability, and undertake appropriate performance refinement.
Deliverable: Final validation and performance assessment of the GPU-based simulation capability.

**WP4 – EMT Model Interoperability and Conversion**

This WP will advance and validate model-import capability to support the use of a user-developed EMT model within the GPU-based

simulation environment. The work will assess conversion integrity, model portability and interoperability, including representative proprietary-model interfaces where appropriate. The capability will be evaluated using a representative supported model and its practical coverage and limitations documented.
Deliverable: Final validation report for model-import capability and integration.

The project will be undertaken in a prototype and validation environment using representative transmission-system test cases and study scenarios. It does not include full enterprise deployment or business-as-usual operational implementation. The project will instead provide validated simulation capability, benchmark evidence, interoperability learning and deployment guidance to inform future adoption.

## Objective(s)

The main objectives of this project are:

· Advance and validate a GPU-accelerated EMT simulation capability that can solve complex EMT simulations in a fraction of the time as CPU-based solvers

· Demonstrate numerical fidelity similar to current commercial solvers via comparing against transient performance and numerical consistency.

· Demonstrate an end-to-end modelling and simulation workflow that enables supported existing EMT model to be used within the GPU-based simulation environment.

## Consumer Vulnerability Impact Assessment

The project has an indirect benefit for consumers in vulnerable situations through improved network planning, system security and cost efficiency. Faster and more comprehensive EMT studies can support better-informed reinforcement and connection decisions, helping reduce unnecessary network expenditure and facilitating the efficient integration of low-carbon technologies. Lower network costs and improved system resilience benefit all consumers, including those in vulnerable situations.

## Success Criteria

The success criteria for this project are:

Work Package 1

Prototype GPU-based EMT simulation capability demonstrated for representative project study cases.

Work Package 2

A test system successfully simulated in both PSCAD and the GPU-based environment, with equivalent topology, control logic, and dynamic behaviour.

Work Package 3

Validation against PSCAD demonstrating waveform fidelity, transient behaviour, and numerical consistency, with computational performance assessed and documented.

Work Package 4

Model-import capability validated on a representative supported model, with conversion integrity, interoperability, coverage and practical limitations assessed and documented.

## Project Partners and External Funding

Hylectra Limited is the main project partner. SSEN-T and NESO are external stakeholders to this project.

## Potential for New Learning

This project is expected to realise:

- A GPU API that can natively handle small-timestep simulations of complex networks
- The feasibility of the method on an industry-available representative test system e.g. IEEE 39-bus system
- The potential end-to-end computational speed improvement of EMT simulations for different scenario complexities

The project's non-confidential learning and validation findings will be disseminated by several mechanisms including:

- Academia/industry workshops
- Conferences/journals

## Scale of Project

This project is centred around computer-based simulations for EMT workflows. This will involve a few GPU-based machines to verify the methodology and performance. This project-scale is appropriate based on the technology readiness of the solution.

## Technology Readiness at Start

TRL2 Invention and Research

## Technology Readiness at End

TRL5 Pilot Scale

## Geographical Area

Warwick, UK

## Revenue Allowed for the RIIO Settlement

N/A

## Indicative Total NIA Project Expenditure

Internal Spend

Stakeholder internal costs, indirect costs, legal – £203,000

External Spend

WP1 – GPU simulation framework: £240,000 | Months 1–9

M1.1 – Framework architecture approved: £60,000 | Month 3

M1.2 – CUDA EMT solver and event handling delivered: £120,000 | Month 7

M1.3 – GPU-resident prototype and profiling baseline delivered: £60,000 | Month 9

WP2 – Model development and PSCAD benchmarks: £106,667 | Months 9–13

M2.1 – Matched GPU and PSCAD benchmark models completed: £58,667 | Month 11

M2.2 – Dynamic scenarios and PSCAD reference results completed: £48,000 | Month 13

WP3 – Validation, benchmarking and tuning: £106,667 | Months 14–17

M3.1 – Fidelity and numerical stability validated: £37,333 | Month 15

M3.2 – Performance benchmarked and bottlenecks addressed: £37,334 | Month 16

M3.3 – Tuned GPU engine and final assessment delivered: £32,000 | Month 17

WP4 – EMT model conversion and interoperability: £186,666 | Months 18–24

M4.1 – Transparent-model import and validation workflow delivered: £84,000 | Month 21

M4.2 – Black-box accommodation and FMI import demonstrated: £74,666 | Month 23

M4.3 – Model-import validation and integration report delivered: £28,000 | Month 24

Total Spend (Internal & External Spend)

£843,000

# Project Eligibility Assessment Part 1

## Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations

Please answer **at least one** of the following:

## How the Project has the potential to facilitate the energy system transition:

The project has the potential to facilitate large scale EMT studies, leading to more robust network build recommendations. This would ensure that network build is better optimised for IBR based generation from renewable sources and large loads.

## How the Project has potential to benefit consumer in vulnerable situations:

n/a

## Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

## Please provide an estimate of the saving if the Problem is solved

n/a

## Please provide a calculation and/or description of the expected benefits of the solution

As this is an early-stage research project, it is too early to meaningfully quantify the financial benefits. The project is intended to provide better evidence for future network investment decisions. Greater confidence in when reinforcement is, or is not, actually required could help avoid unnecessary investment in network assets, such as additional voltage-support equipment. The main financial benefit would therefore come from avoiding or delaying reinforcement that would otherwise have been undertaken.

## Please provide an estimate of how replicable the Method is across GB

The project learning and validated approach are expected to be highly replicable across GB electricity transmission networks. The GPU-based EMT capability can support different network models and study applications, with deployment arrangements agreed as appropriate.

## Please provide an outline of the costs of rolling out the Method across GB.

Following successful validation, wider rollout would involve deployment, integration, computing infrastructure and associated implementation costs. The scale of these costs would depend on each user's requirements. The approximate cost of a high-performance compute workstation is £5,000. The number of these workstations required is dependent on the needs of the user.

## Requirement 3 / 1

Involve Research, Development or Demonstration

Projects must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

Involve Research, Development or Demonstration - Please select all that apply

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☑ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☑ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

### Specific Requirements 4 / 2a

### Please explain how the learning that will be generated could be used by the relevant Network Licensees

The non-confidential learning from this project can inform Network Licensees on the application, validation and potential benefits of GPU-accelerated EMT simulation. The key learnings are therefore relevant across the industry.

n/a

### Is the default IPR position being applied?

☑ Yes

## Project Eligibility Assessment Part 2

### Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed. Networks must explicitly mention similar projects that they have considered and how these differ.

### Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

No comparable GPU-based EMT simulation capability has previously been developed for GB transmission-system applications through a GB network innovation project; therefore, this represents a novel NIA project.

### If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

N/A

## Additional Governance And Document Upload

### Please identify why the project is innovative and has not been tried before

GPU-accelerated EMT simulation is an emerging area, and its application and validation for GB transmission-system studies remains at an early stage. This project is innovative in applying and validating GPU-accelerated EMT simulation for representative transmission applications, with a focus on numerical fidelity, computational scalability and interoperability with existing EMT modelling workflows. The project will generate evidence on feasibility, performance and practical deployment considerations required before wider operational adoption.

### Relevant Foreground IPR

Expected Relevant Foreground IPR may include project-specific validation methods and results, benchmark and test cases developed for the project, performance and scalability assessments, interoperability and deployment learning, validation reports, and other project-specific outputs generated through the NIA activities.

Background IPR may include Hylectra's pre-existing and independently developed software, methods, tools, libraries, model-conversion capabilities, documentation and know-how. Such Background IPR remains the property of Hylectra.

Where Hylectra Background IPR is necessary for the use of Relevant Foreground IPR, access to or licensing of such Background IPR will be subject to the agreed project IPR arrangements and, where applicable, provided on fair and reasonable commercial terms to be negotiated in good faith between the parties.

## Data Access Details

Data generated through the project will be made available to interested parties in accordance with National Grid Electricity Transmission's data sharing and information governance policies and the requirements of the RIIO-3 NIA Governance Document.

Requests for project data may be submitted through the contact details provided within the project registration and published project reports. Where appropriate, non-confidential project outputs, methodologies, findings, and aggregated datasets will be made publicly available through project dissemination activities, final reports, and relevant industry platforms.

Certain data may not be released where it contains commercially sensitive information, confidential information belonging to project partners or third parties, security-sensitive network information, personal data, or information subject to intellectual property or contractual restrictions. Where full disclosure is not possible, a suitably anonymised, redacted, or aggregated version of the data will be provided where reasonably practicable.

All data requests will be assessed in accordance with applicable legal, regulatory, confidentiality, cybersecurity, and data protection requirements.

## Please identify why the Network Licensees will not fund the project as a part of it's business and usual activities

This project involves the advancement and validation of a GPU-accelerated EMT simulation capability for Power Systems Analysis. It is not a business as-usual activity; there are notable technical and deployment risks, and the project outcomes are not guaranteed to be successful.

## Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks (e.g. commercial, technical, operational or regulatory) associated with the project

The nature of a research programme means it inherently carries a high risk that the research may be unsuccessful. Therefore, this project cannot be carried out as business and usual activities.

## This project has been approved by a senior member of staff

☑ Yes