CReDo+

Extension to new climate risks
Round 2 Alpha Phase end of project meeting

25 March 2024

AGENDA

Project delivery overview

- Project plan
- Meeting project specific conditions
- Summary of project activities

Positive highlights

- Successes
- Risks & mitigations
- Lessons learnt

Next steps for CReDo+

- Comms and engagement
- Beta proposal

Appendix

- Work package description

Name	Definition
CReDo	Digital Twin product and technology
CReDo+	Ofgem Strategic Innovation Fund Round 2 Alpha Phase project that develops the CReDo product

PROJECT DELIVERY OVERVIEW

Project plan

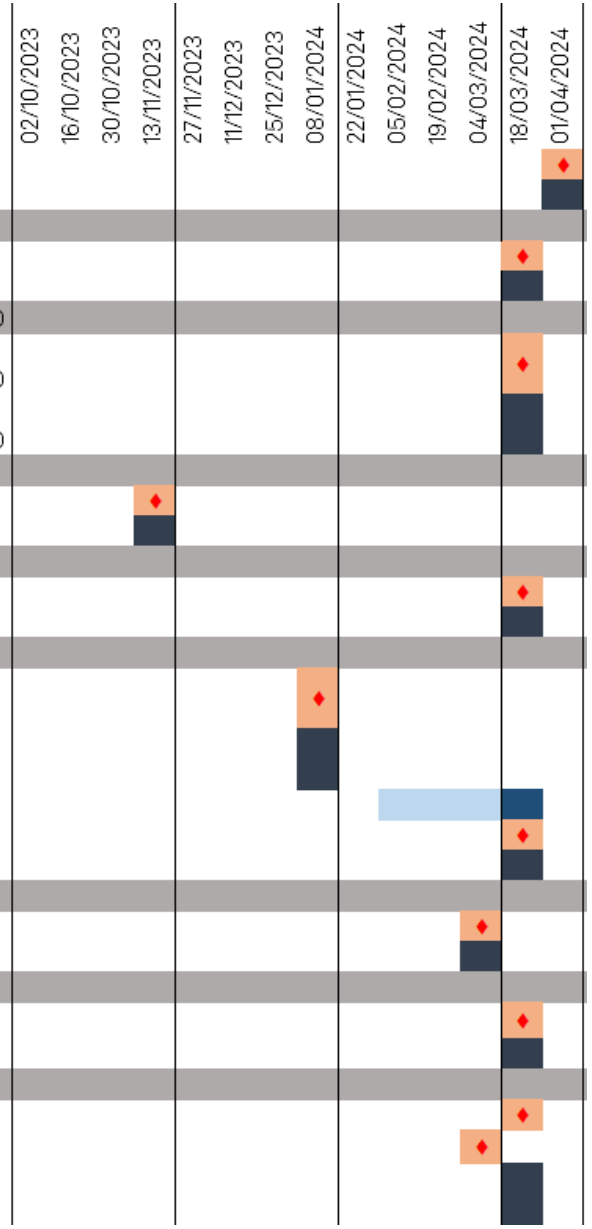
Meeting project conditions

Summary of project activities

FINAL PROJECT PLAN

High level project plan

Purpose	WP	Task	Lead
Project Enablement:	WP1 Project Management	D1.1: Project closure	CPC
		M1.1: Project completion	CPC
	WP2 UKPN data, asset and testing support		UKPN
		D2.1: UKPN engagement and data gathering	UKPN
		M2.1: UKPN engagement and data gathering	UKPN
	WP3 NG ESO data, asset and testing support		NG ESO
		D3.1: NG ESO engagement of user research, design validation and prototype testing	NG ESO
		M3.1: NG ESO engagement of user research, design validation and prototype testing	NG ESO
Minimum Viable Data and Modelling	WP4 CReDo asset and system modelling		CPC
		D4.1: Preliminary asset, system, and climate data and models	CPC
		M4.1: Preliminary phase	
Prototype Delivery			CPC
		D4.2: Asset, system, and climate data and models	CPC
		M4.2: Full phase	CPC
	WP5 CReDo extreme heat prototype		
		D5.1: Extension of CReDo ontologies for asset and hazard data for extreme heat scenario	CMCL
		M5.1: Extension of CReDo ontologies for asset and hazard data for extreme heat scenario	CMCL
		Run demonstrator of CReDo prototype for extreme heat scenario	CMCL
		D5.2: CReDo extreme heat demo	CMCL
		M5.2: CReDo extreme heat demo	CMCL
	WP6 Digital elicitation tool small scale prototype		STFC
		D6.1: Digital elicitation tool prototype	STFC
		M6.1: Demonstrate prototype tool capabilities	STFC
Business Case and Engagement	WP7 Business Case and Cost Benefit Analysis		CPC
		D7.1: Cost Benefit analysis and business case	CPC
		M7.1: Cost Benefit Analysis and Business Case	CPC
	WP8 Engagement & Dissemination		CPC
		D8.1: Project report	CPC
		D8.2: Workshop to showcase project with key representatives	CPC
		M1: Engagement and dissemination	CPC
		M2: Support on engagement and dissemination across sectors	CPC



CONDITIONS

Projects specific conditions

- **Condition 1:** The Funding Party must not spend any SIF Funding until contracts are signed with the Project Partners named in Table 1 for the purpose of completing the Project.
  - *The signature of contracts took a significant amount of time at the beginning of the project. As the implementation of the project was at risk due to the delay, some partners began working at risk (without incurring costs to SIF) until all contracts were in place.*
- **Condition 2:** The Funding Party must report on the financial contributions made to the Project as set out in its Application. Any financial contributions made over and above that stated in its Application should also be reported and included within the Project costs template.
  - *Partners have delivered on budget with financial contributions as planned.*
  - *See next slide (Slide 6).*
- **Condition 3:** The Funding Party must make reasonable endeavours to participate in all meetings related to the Project that they are invited to by Ofgem, UKRI and DESNZ during the Alpha Phase.
  - *Project representatives have attended all UKRI meetings.*
- **Condition 4:** During the Alpha Phase, the Funding Party must engage with the team behind the round 2 Alpha Phase Project 'NIMBUS' to examine areas of potential commonality and overlap, and how the Projects could inform each other on their findings. Innovate UK can facilitate an introduction if necessary.
  - *Project representatives engaged with "Nimbus" on three occasions. (see slide 17)*

MEETING PROJECT SPECIFIC CONDITIONS

Total amounts are estimates before the end of the project

Taken from Project Direction (or latest amended Project Direction)				
Project partner name	Total project costs (£)*	Project Compulsory Contribution (£)**	Total SIF Funding requested (£)***	Actual spend (£)****
National Grid ESO	£12,872.00	£2,573.00	£ 10,299.00	£12,872.00
CMCL Computational Modelling Cambridge Ltd	£145,000.00	£14,500.00	£130,500.00	£145,000.00
Connected Places Catapult	£221,195.00	£22,120.00	£199,075.00	£221,195.00
Science Technology Facilities Council	£102,480.00	£10,248.00	£92,232.00	£102,480.00
UK Power Networks	£73,750.00	£ 8,000.00	£ 65,750.00	£ 69,146.82

SUMMARY OF PROJECT ACTIVITIES

WP 1: Project management

- Although the project started with a slight delay, the project team have been able to keep on track of project implementation and the completion of deliverables. For this, the team introduced a specialised product management software platform and adopted Agile and Scrum working practices. This helped the team break down tasks within each Work Package (WP) to deliver in short sprints and included points to review the work done and start showcasing outputs.
- A joint workspace was set up on UK Power Networks' SharePoint where key documents were stored, including outputs for each of the WP.
- In addition to the weekly project management meeting, the project team attended wider CReDo joint meetings including a monthly Plenary session.

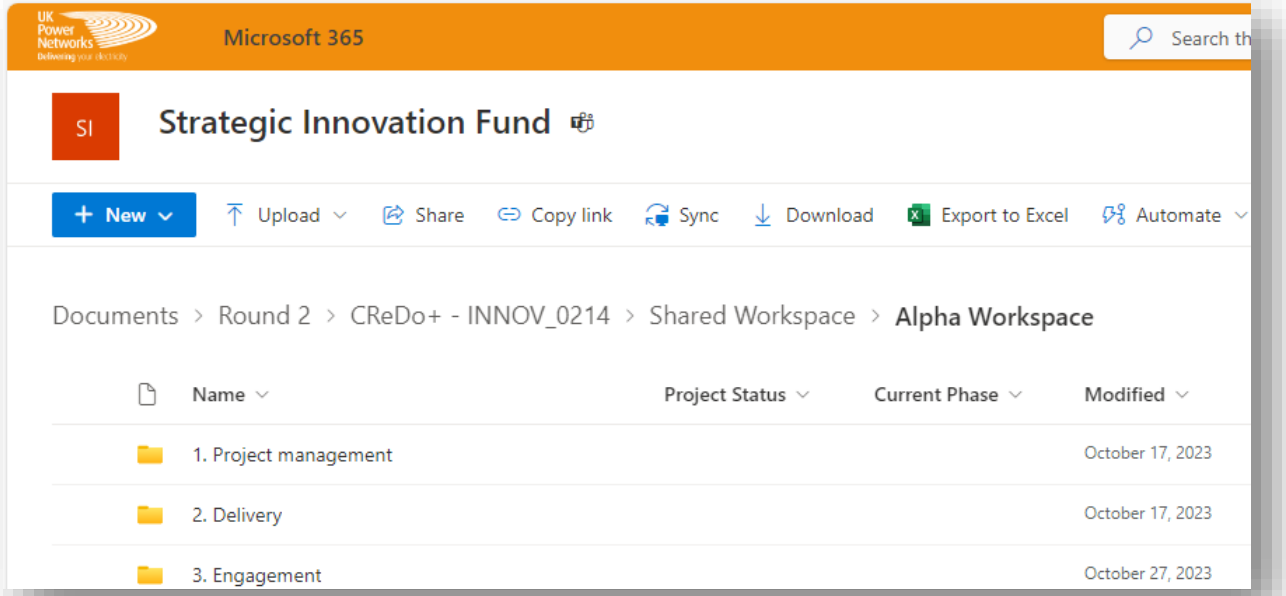


Figure 1: Example of SharePoint workspace

SUMMARY OF PROJECT ACTIVITIES

WP 2 : UK Power Networks data, asset and testing support

- The project team managed to plan stakeholder engagement effectively so UK Power Networks engineers, operators, data analysts and senior managers were able to be involved in the following activities:
  - Structural elicitation interviews
  - Probabilistic elicitation interviews
  - Data triage interviews
  - Cost benefit analysis interviews
  - User journey mapping sessions
  - Stakeholder and persona mapping, and exploration of user needs

- The project team also identified 35 different datasets which would be necessary for the project, and which were triaged with the Enterprise Data Management team at UK Power Networks.
- The triaged datasets, or where necessary examples, were shared securely with specific members of the project team. This allowed modellers and designers to conduct the appropriate analysis to support the delivery of project activities.
- As part of the stakeholder mapping sessions, the project team conducted teach ins about the CReDo product and its future with senior stakeholders within UK Power Networks. This work has formed the basis of user persona mapping for the product for the Beta Phase project.

SUMMARY OF PROJECT ACTIVITIES

WP 3 : National Gas Electricity System Operation (NG ESO) asset and testing support

- The CReDo+ project team held four workshops with NG ESO. Research conducted to better understand their needs and validate the design hypothesis of the CReDo digital twin, modelling and use cases:
  - NG ESO half day workshop 1: 26/01/2024
  - NG ESO half day workshop 2: 06/02/2024
  - NG ESO workshop 3: 04/03/2024
  - NG ESO workshop 4: 27/03/2024
- The half-day workshops focused on gaining a deep dive understanding of what NG ESO's resilience problems were, and how that was compatible to what CReDo is trying to solve and the approach the CReDo+ project is taking when it comes to modelling and data sharing.
- Validation of NG ESO CReDo use cases, and the NG ESO and Scenarios for Extreme Events collaboration opportunities to be concluded in last Alpha Phase workshop (27/03/2024).
- During the workshops, it was found that NG ESO:
  - Are interested in solving resilience problems across the whole system level for energy on a national scale.
  - Were interested in CReDo approaches to asset risk modelling.
  - Have experience with modelling supply and demand.
  - Have differing approaches on data sharing and tentative about sharing across sectors.
  - Are interested in economic and societal impacts and reporting.
  - Are most concerned about cyber-attacks and extreme weather.
- Opportunities for continued partnership:
  - CReDo can provide system wide risk starting from granular asset modelling and give a cross sectors understanding.
  - CReDo can output impacts and metrics for reporting.
  - NG ESO can share knowledge of supply and demand modelling to enhance CReDo.
- Virtual Energy System engagement on 24/01/2024 provided understanding of development timeline, use cases, and opportunities for sharing learnings around data sharing.

SUMMARY OF PROJECT ACTIVITIES

WP 4: CReDo asset and system modelling

- Expert elicitation was used to obtain the necessary information to build asset models for grid, primary and secondary substations, and overhead lines, as well as identifying the risk of failure associated to them under a set of extreme heat weather scenarios.
- The project was able to collect expert knowledge on risks in the following areas, used to build the models:
  - Threats to telecommunication assets
  - Threats to electricity supply
  - Mitigation measures
- A first iteration of the technology needed to use models based on Bayesian networks was developed and helped support the demonstrator capability of CReDo. This was implemented in a Python codebase.

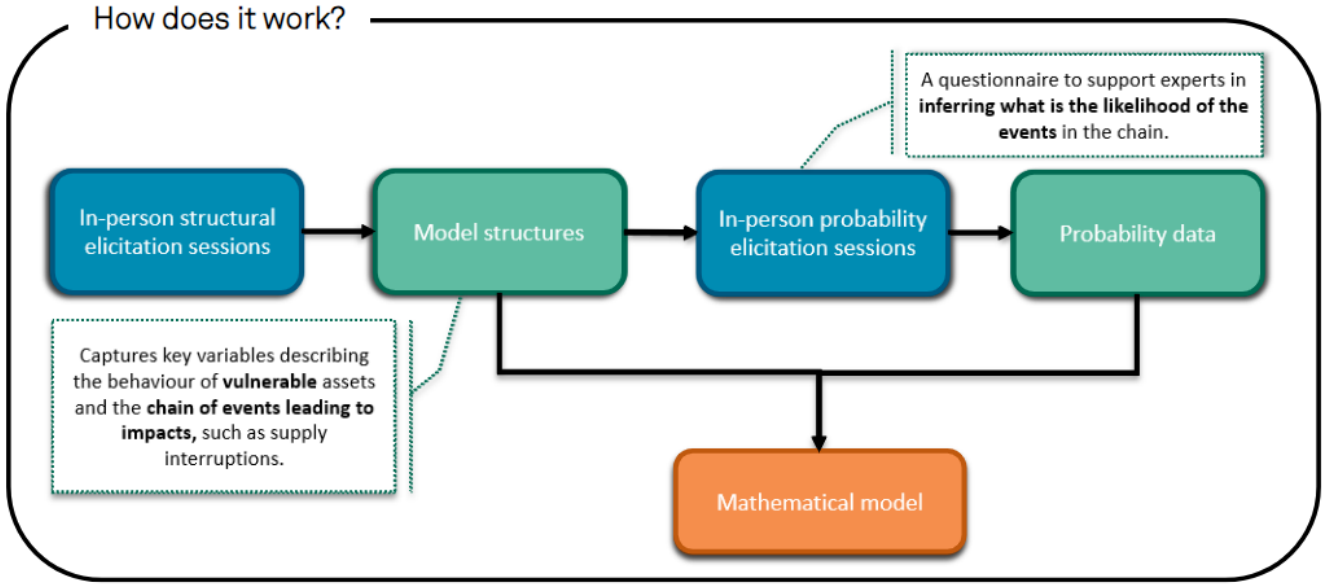


Figure 2: Example of full stage of expert elicitation

SUMMARY OF PROJECT ACTIVITIES

WP 5: CReDo+ extreme heat prototype

- The team has undertaken significant work for CReDo to integrate and enable interoperability between weather data for extreme heat events, models describing the effect of extreme heat on power distributions assets, and data describing the assets. These include:
  - Developing and expanding the ontologies that underpin CReDo to represent information as knowledge graphs. This allows CReDo to include additional data models without having to change the code used.
  - Modifying CReDo to allow the integration of weather event data which now allows storage of time-resolved multidimensional scientific data.
  - Integrating failure models in collaboration with WP4.
  - Updating CReDo's user interface to support visualisation of time-resolved extreme heat (temperature identified by orange) weather event data.

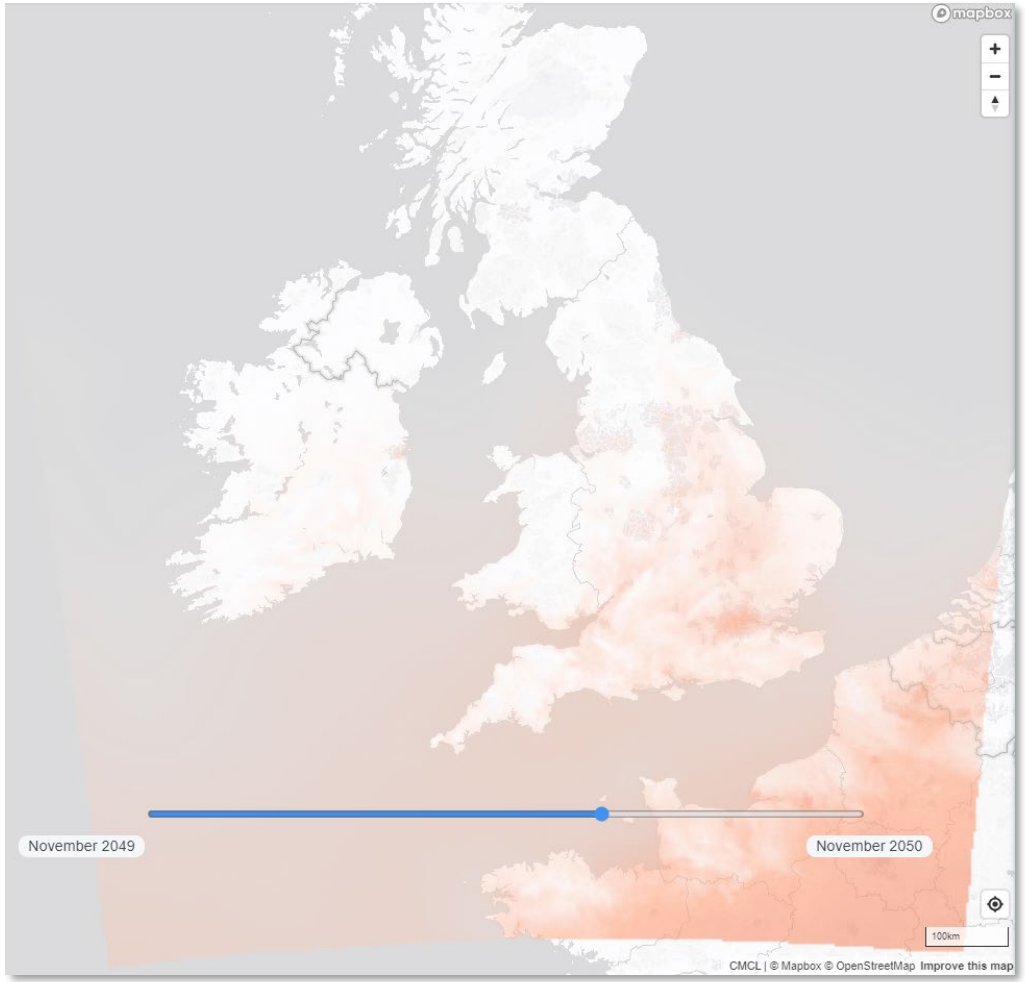


Figure 3: Example of maximum daily temperature in 2050 visualised over UK. (Orange signifies temperatore)

SUMMARY OF PROJECT ACTIVITIES

WP 6: Digital elicitation tool – small scale prototype

- The project team initially went through the process of designing a high-fidelity “clickable” wireframe that allowed to:
  - Identify and refine user personas (i.e. elicitation leader and elicitation participant).
  - Map out a user journey.
  - Complete a first design of how an interface to support the main tasks in the user journey could look like.
  - In this design, users would be able to create their own specific models without a limit to the size and complexity they need.
- The project team then developed a first prototype of the digital elicitation tool that proves the technology can be used in the following ways:
  - A user can use the prototype to construct a failure model. This includes, building a model structure and questionnaire.
  - A user can input a set of answers to the questionnaire (i.e. probabilities).
  - A user can obtain a machine-readable output that contains all key information about the above steps.
  - It is important to understand that very significant work is still necessary to take the tool to a state where it could support building models in a real and sustainable way.
- A digital elicitation feedback session with UK Power Networks staff took place on 5 February 2024.

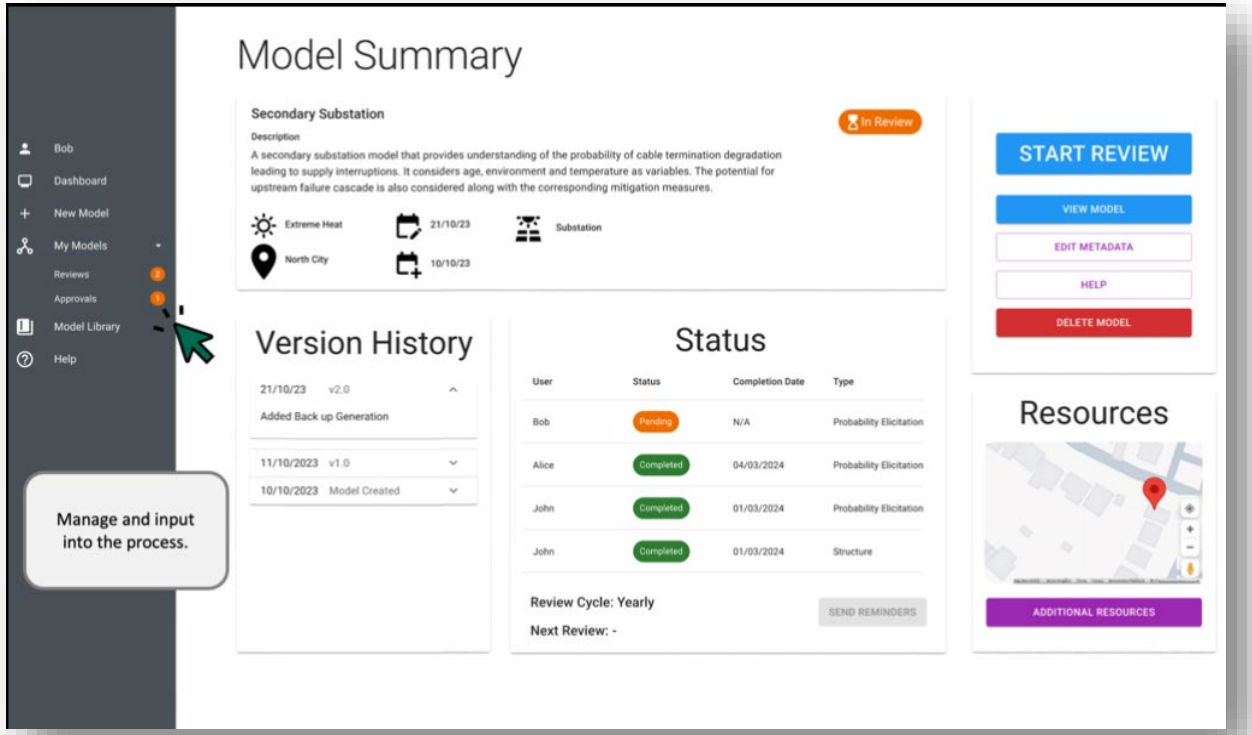


Figure 4: Example of detailed wireframe of prototype

SUMMARY OF PROJECT ACTIVITIES

WP 7: Business case and cost benefit analysis

- The team completed Ofgem's Cost Benefit Analysis template with a proposed option of a multi-network, cross-sector, national scale CReDo Digital Twin.
- The template includes qualitative, Green-Book-aligned commentary on Ofgem's requested areas. It also included a logic model of how outcomes and impacts are delivered across different stakeholder groups in the short-, medium-, and long-term.
- It also includes numeric modelling on avoided impacts, investment costs and summary calculations (including inputs).
- Feasibility and confidence have been two key criteria applied to the quantification of the different scenarios, resulting in a conservative forecast.
- *Benefit-cost ratio is over 50 with benefits in £billions over a 2070 investment period.
- UK Power Networks data and expert advice enhanced the methodology.

**The BENEFIT-COST ratio is then BENEFIT divided by COST.*

Baseline	Option 1
Blanket Investment, Low-Mid Budget (Counterfactual): The assumed counterfactual against which to compare CReDo. The decision model for making resilience investments is for asset owners to make blanket investment across all assets with no prioritisation considered. Where alternative measures are available for an individual asset, they can invest on middle-cost measure (if three measures are available) or the low-cost measure (if two measures are available). The option relies on assumptions about the decision models and budget constraints in asset owners.	Blanket Investment, High Budget: The decision model for making resilience investments is for asset owners to make blanket investment across all assets with no prioritisation considered. Where alternative measures are available for an individual asset, they invest on the highest cost measure.
Option 2	**Option 3**
Siloed Digital Twin: A within-network only digital twin that any asset owner may have – this provides specific knowledge of asset criticality within the asset owner's own network, but no insight into cross-sector asset criticality or interconnections. The decision model for making resilience investments is to assess the criticality ranking of the assets in their individual network and make prioritised investment decisions accordingly – the Benefit Cost Ratios for each possible investment are ranked and prioritised.	Connected Digital Twin CReDo (intervention): The proposed intervention. A cross-sector digital twin with a full systems-view of asset criticality, based on cross-network interconnections. The decision model for making resilience investments is for CReDo to model the interconnections and criticality rankings of all assets in all available asset owners' networks and make prioritised investment recommendations accordingly – the Benefit Cost Ratios for each investment are ranked and prioritised.

Figure 5: Options being considered for the CBA

SUMMARY OF PROJECT ACTIVITIES

WP 8: Dissemination and engagement – CReDo+ Resilience Working Group

- The CReDo+ Resilience Working Group (RWG) was established as part of Alpha Phase to share insights from the project. It was open to energy networks and organisations and met four times during the project.
- Attended by National Grid Energy System Operator (NG ESO), Scottish and Southern Electricity Networks (SSEN), National Grid Electricity Transmission (NGET), Northern Gas Network (NGN), Southern Gas Network (SGN), Cadent Gas, National Grid Electricity Distribution (NGED), SP Energy Networks (SPEN), National Gas, Energy Networks Association (ENA), Electricity North West (ENWL), Northern Powergrid.
- Overall, the Resilience Working group has been well received in the Strategic Innovation Fund (SIF) community and the CReDo+ team have received positive feedback from participants on the knowledge sharing and engagement in the group.

Meeting	Date	No. Of non-CReDo+ participants	Session overview
Meeting 1	14/12/2023	15	Overview of the Resilience Working Group and presentation on CReDo+ Alpha phase
Meeting 2	18/01/2024	16	Presentations from SIF projects: NIMBUS (SSEN), Scenarios for Extreme Events (NG ESO), WELLNESS (NGET)
Meeting 3	15/02/2024	12	Presentations from SIF projects: Predict4Resilience (SP Energy Networks), CommsConnect (UK Power Networks) Discussion: Emerging themes for potential collaboration across SIF projects
Meeting 4	12/03/2024	16	Presentation on CReDo+ Alpha: key findings and developments, approach to Beta Phase project, areas for potential collaboration with network partners

SUMMARY OF PROJECT ACTIVITIES

WP 8: Kind words and feedback from the Resilience Working Group partners

"Just to say thank you for inviting us for this to this working group … thank you for facilitating … you were the first to do it." <followed by 👍and 👏in agreement>

National Grid Electricity Transmission

"I am super keen to work close with you."

SP Energy Networks

"We would like to be part of CReDo to understand if there are any efficiencies we can gain from the resilience planning you're doing, and the holistic approach you're using to increase resilience across the energy sector."

Cadent Gas

"The reason we want to be part of CReDo is that … we want a common tool across all networks that demonstrates to the regulators and customers that we're coordinating effort to improve resilience in a consistent way, and we're not duplicating effort."

Scottish and Southern Electricity Networks

"The collaboration and holistic view across sectors is really important for everything we're trying to do going forwards, so this is crucial."

Northern Gas Networks

"CReDo is a massive digital twin project gaining a lot of traction, you should speak to them if you want to know more about digital twins."

UK Power Networks monitoring officer internal comms

SUMMARY OF PROJECT ACTIVITIES

WP 8: Wider dissemination and engagement

- Dissemination of CReDo+ Discovery and Alpha Phase lessons and findings across sectors was also done by participating in the following events:

Date	Event
29/06/2023	Roundtable with NGET, Lawrence Livermore National Laboratory, US Department of Energy, North America Electric Reliability Corporation
31/10/2023	Energy Innovation Summit: UK Power Networks Stand
10/10/2023	Mott Macdonald Carbon Crunch (London)
18/10/2023	GovTech (London)
29/11/2023	RESIST European media briefing online
11/12/2023	Engagement with Howden Group (insurance and risk)
09/01/2024	What is a Digital Twin? BBC World Service - Business Daily, What is a digital twin city?
17/01/2024	Open Agile Smart Cities, Rotterdam

Date	Event
30/01/2024	Westminster Policy Forum on Flooding
07/02/2024	Digital Twin Conference
20/02/2024	Energy Networks Association Resilience Working Group
21/02/2024	UK Power Network – Net Zero Networks
14/04/2024	Digital Twin Partnership Australia webinar
19/03/2024	Ofgem Resilience Teach-in
21/03/2024	Connected Places Catapult Summit

SUMMARY OF PROJECT ACTIVITIES

WP 8: Engagement with other projects (SIF, Network Innovation Allowance (NIA), Ofwat Water Breakthrough Challenge)

NIMBUS - SSEN

- Engagements on 28/11/2023, 22/02/2024, 29/02/2024.
- Project focused on asset degradation for predictive maintenance.
- Issue with low quantity of inspection data caused challenges.
- Concluded tacit knowledge, expert opinions and elicitation methods were highly valuable (approach taken by CReDo+).
- Similar approaches to data engineering (ontologies etc.)
- Concluded projects would be complementary.

NIPRAM – NGET (NIA)

- Engagement on 29/02/2024.
- Project focused on response and re-energisation assurance as part of asset management strategy.
- Comparison of Bayesian elicitation methods to quantifying risk.
- NGET moving away from qualitative risk assessment.

Scenarios for Extreme Events (SfEE) – NG ESO

- Engagements on 26/01/2024, 06/02/2024, 04/03/2024, 27/04/2024.
- Project focused on impacts to energy network from range of events (cyber, disruption, weather) – non-weather resilience complementary to CReDo climate resilience.
- Using qualitative scenarios compared to CReDo quantitative asset risk modelling, both then model cascading impacts.
- Output is impacts and metrics for reporting. CReDo aims for costed resilience investment decision making, in addition to reporting.

CReDo Ofwat – Anglian Water

- Engagements throughout Alpha Phase.
- Processing extreme heat data to create heat hazard risk maps, which can be used by the risk models elicited for energy assets.
- Developing a lower barrier to entry visualisation for users to access risk model outputs, to act as a gateway to CReDo onboarding.
- Universal CReDo data model and ontology that works across energy and water data, assets, and models.

POSITIVE HIGHLIGHTS

Successes

Risks & mitigations

Lessons learnt

SUCCESSES

Elicitation engagement

- Seven structural elicitation sessions leading to:
  - Preliminary model structures for primary and secondary substations (inc. Indoor and outdoor substations).
  - First iteration of more refined model structures for grid/primary substations, secondary substations, pole system, overhead transmission lines and underground lines. These cover 10 different potential heat derived risks and two mitigation measures.
- Five probability elicitation sessions where nine questionnaires were covered to quantify risks in relation to:
  - Remote Terminal Units (RTUs), protection relays, transformers, cable insulation damage, cable termination degradation and switchgear.
  - These probability values could be used in implementing a first iteration for grid, primary and secondary substations, pole systems and overhead lines models.
- Experts from several teams were interviewed within the asset management teams and network operations areas.
- Implementation of the preliminary models was completed allowing for an extreme heat CReDo+ demo with simplified underlying logics for cascading.
- Demo of the Digital Elicitation Tool has been scheduled for Thursday 28/03/2024 in the CReDo Plenary with our partner asset owners

SUCCESSES

Extreme heat demo

- During the CReDo Plenary session of the 29/02/2024 the team showcased the extreme heat demonstrator to UK Power Networks, Anglian Water and BT Group representatives.
- The demonstrator showed end-to-end integration of heat data, connected asset data, asset failure models and system wide cascade models to show the failure cascade from extreme heat.
- This information was visualised on a map of Great Britain, layering heat and asset data. The visual here uses synthetic asset data.

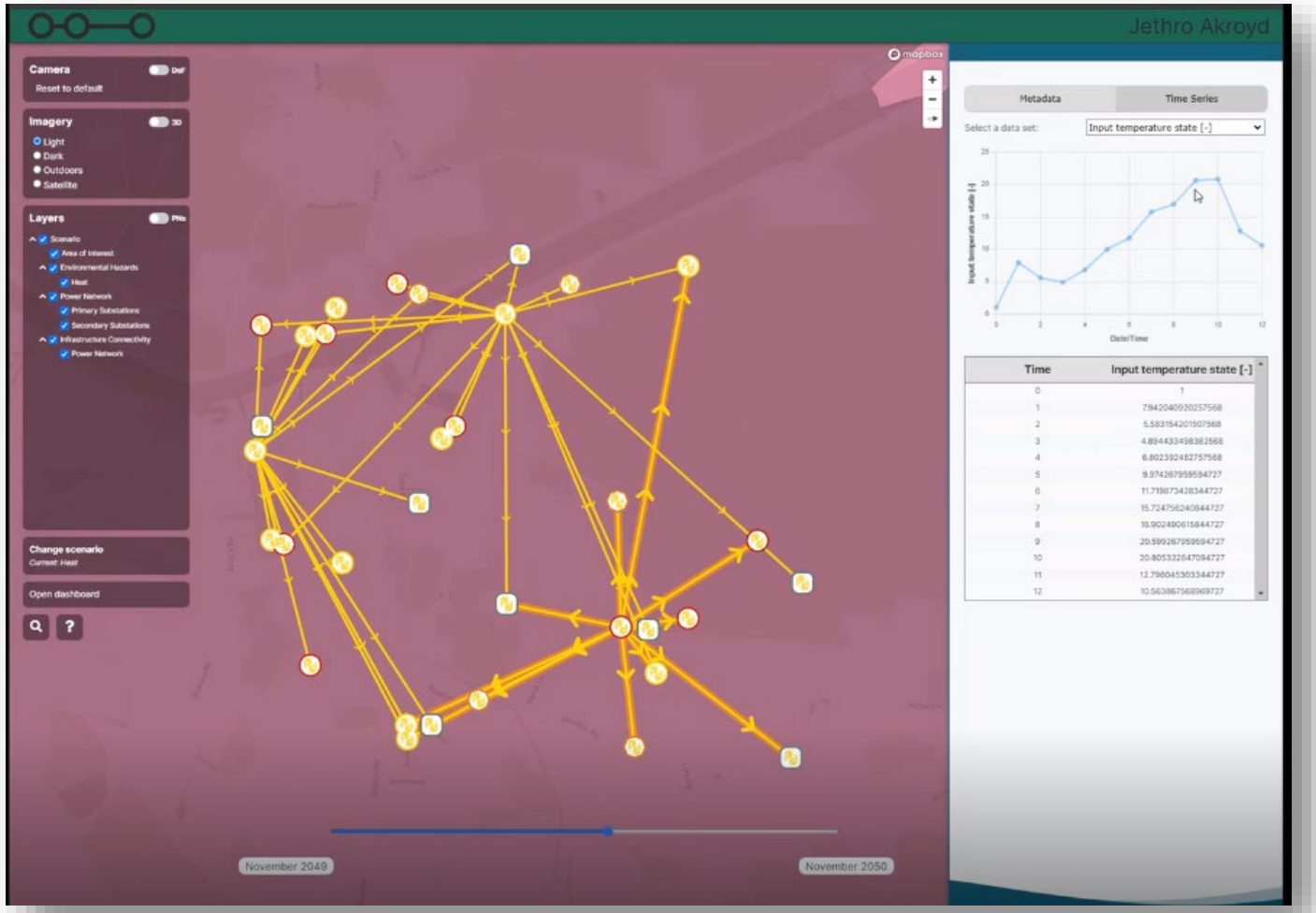


Figure 6: Example of Demonstrator visualization

SUCCESSES

Agile ways of working and Jira enabling a successful delivery

- Jira (product management software) was successfully embedded into the team's day-to-day ways of working. The project team used Jira to run the project; track changes, activities and dependencies; and work asynchronously across work packages.
- A 'Microsoft Teams-first' approach was taken with Microsoft Teams chats set up across all internal and external project team members to support the work packages for clear and efficient communication. Daily standups for each work package and across work packages were established via chats to enable communication whilst reducing time commitments of the project team.
- Regular cadenced meetings according to Agile ways of working based on Scrum principles were established and worked into two-week sprints. This included Standups, Sprint Planning, Demo Playbacks, Retrospectives and Backlog Prioritisation.
- We fostered an open behaviour of transparency and psychological safety including demoing of work in progress across work packages to reduce silos and course correct regularly throughout the project.
- As of the 20/03/2024, across the eight work packages:
  - 259 work items have been created and moved into sprints.
  - 194 work items have been completed.

RISKS & MITIGATIONS

Prominent challenges faced by the project and associated mitigation steps actioned – all closed

Challenges	Work Packages (WP)	Mitigation
Delivery of a complex project required co-ordination between partner organisations and WP leaders	WP1 / WP8	• Adoption of agile ways of working. • Implementation of scrum framework through application of two-week sprints and associated meeting cadence. • Utilisation of Jira for collaboration and monitoring.
Exploration of raw climate data revealed a lack of data around the higher part of the temperature range of interest (40-45 deg. C)	WP4 / WP5	• The elicitation process uncovered a collection of heat-derived risks. Synthetic data could therefore be used to represent 'heat wave events' facilitating model outputs for demonstration purposes.
Delayed delivery of sample asset and extreme heat data	WP4 / WP5	• Delivery of the required information was split to include a preliminary phase, ensuring timely delivery of the minimum information required to commence work on dependent activities.
Delayed project start due to contractual discrepancies resulting in a shortened timeframe for delivery	WP1 / WP6	• The risk was escalated, and legal teams proactively engaged to encourage a swift turn around and to get contracts signed. • Work on WP6 initially started at risk until the contract was fully in place.

RISKS & MITIGATIONS

Prominent challenges faced by the project and associated mitigation steps actioned – all closed

Challenges	Work Packages (WP)	Mitigation
Lack of understanding of Digital Elicitation Tool (DET) amongst UK Power Networks stakeholders during user testing	WP6	• Valuable time with stakeholders was instead utilised to further develop the potential user base understanding of the core purpose and functionality of CReDo and the DET. • Remaining prototype testing was conducted with an in-house elicitation expert.
Lack of data publicly available to quantify the scale of how extreme heat benefits compared to flooding benefits as part of the Cost Benefit Analysis (CBA)	WP7	• Desk research (academic journals, industry reports, etc.) and data gained from interviews were applied to the CBA. • Sensitivity analysis was applied to test how sensitive results were to changes in input, with methodology and assumptions stated in the model and supporting narrative.
CBA template supplied by UK Research & Innovation for Beta was issued at the end of Feb, followed by an unexpected update to the template on 13/03/2024	WP7	• A standards-based approach was initially taken by reviewing the CBA approach in UK Power Networks, and green book standards. • With the timing of the template update, there was a significant risk WP7's review process would be delayed, leading to an agreement that the CBA model could be transferred to the new template in a later phase.

LESSONS LEARNT

1. Contracting was delayed and a legal review of contractual terms and issues from project partners has been conducted by UK Power Networks to reduce the likelihood of repeated delays in future project phases.
2. Whilst the team believed that expert elicitation could be made simpler by developing a digital elicitation tool, the activity of defining probabilistic elicitation is a complex concept which is not readily understood by operational subject matter experts or asset managers. There may have to be an exercise to develop capabilities within the organisation to be able to move to a wider use of the tool in the next phases.
3. The project team decided to implement simpler models under WP4 to help reduce the time spent on expert elicitation interviews and data processing and focus on the technology development needed to use Bayesian networks and help demonstrate CReDo's capabilities sufficiently for this stage. This decision has helped push technology development for CReDo, as it was unable to run these models before Alpha Phase and will aim to be further refined during the implementation of Beta Phase.
4. To ensure a more structured project delivery, the team decided to implement Agile work practices and the Scrum framework. This not only led to a more efficient delivery but also contributed to excellent communication within the consortium. As a result, these practices will be implemented in next phases, ensuring good communication and a better breakdown of work.
5. Need data about potential future likelihood of extreme heat events and risks as there's no significant historic data.
6. The CReDo+ RWG was a good platform to share lessons learnt across Alpha Phase projects which would have struggled to do this bilaterally. It would be recommended that a similar set-up is considered for the next phase as a way of ensuring that any emerging compatibility between projects can be identified promptly.

NEXT STEPS FOR CReDo+

Ongoing engagement and communications

Beta proposal

ENGAGEMENT AND COMMUNICATIONS

Ofwat Water Breakthrough Challenge – Catalyst Phase – Anglian Water – completing June 24

- We are taking our learnings from Alpha Phase and continuing them through the complementary project in the water sector. The risk modelling will be improved. We are also processing new types of heat data. These learnings will feed back into future phases of work in the energy sector.

Engagement

- CReDo+ Resilience Working Group
  - Other networks have expressed interest in continuing with the CReDo+ Resilience Working Group during Beta Phase, including SSEN, NGET, Cadent, SGN, NG ESO
- We plan to have ongoing conversations with Ofgem and the Adaptation Committee of the Committee on Climate Change on resilience metrics and risk cascades.
- We will continue speaking at conferences about CReDo.

Communications

- We will look to increase the visibility and impact of CReDo across sectors through content creation and promotion pushed across digital communications channels. This might include blogs, social media posts, and working with trade publications to promote CReDo with industry.

BETA PHASE PROPOSAL OVERVIEW

CReDo+ Goal

Scale CReDo technology across the energy sector to understand interdependencies and cascading climate risk to support decision making in resilience investment.

Create a sustainable platform to enable further use cases and sectors post-Beta Phase.

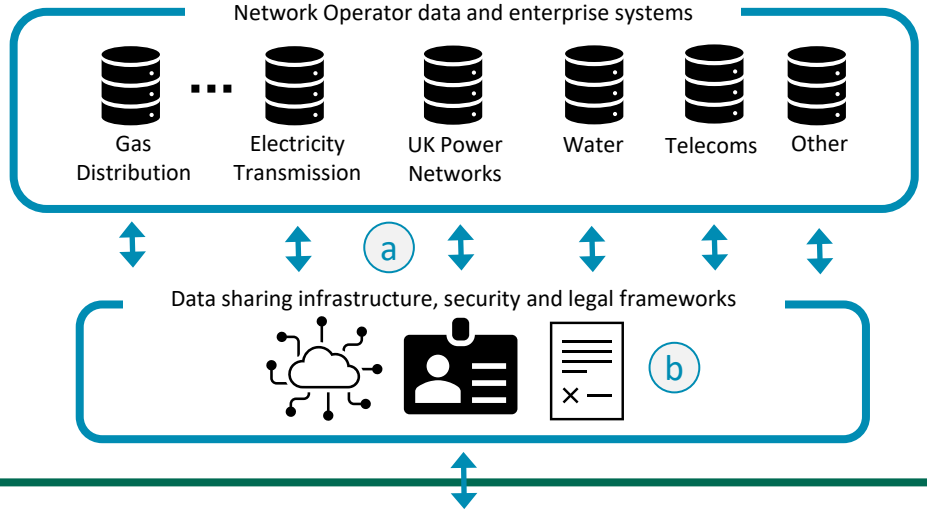
CReDo+ Needs

- Scalable asset risk modelling
- Data sharing infrastructure
- Collaboration
  - Network and asset data across energy licensees
  - Experts and users
  - Learnings and solutions

CReDo+ Will

- Connect network and asset data with Digital Twin and Knowledge Graph technologies by developing secure data sharing and legal frameworks
- Gather and process data on future extreme weather (flooding, heat, wind extension)
- Develop scalable asset risk models to capture failure from weather, encoding expert opinions with a digital elicitation tool
- Model interdependencies and cascading risk with system-wide models
- Co-design a suite of decision intelligence tools to support strategic investment planning and resilience reporting with AI and metrics
- Co-develop user-centred applications to provide map, decision support and dashboard interfaces for CReDo users
- Provide safe and secure access to users including network operators (planners, asset managers, engineers, decision makers)
- Enable data and insights to be shared back on a need-to-know basis to network operator systems, regulators and government, and wider digital ecosystem through API marketplace

BETA PHASE

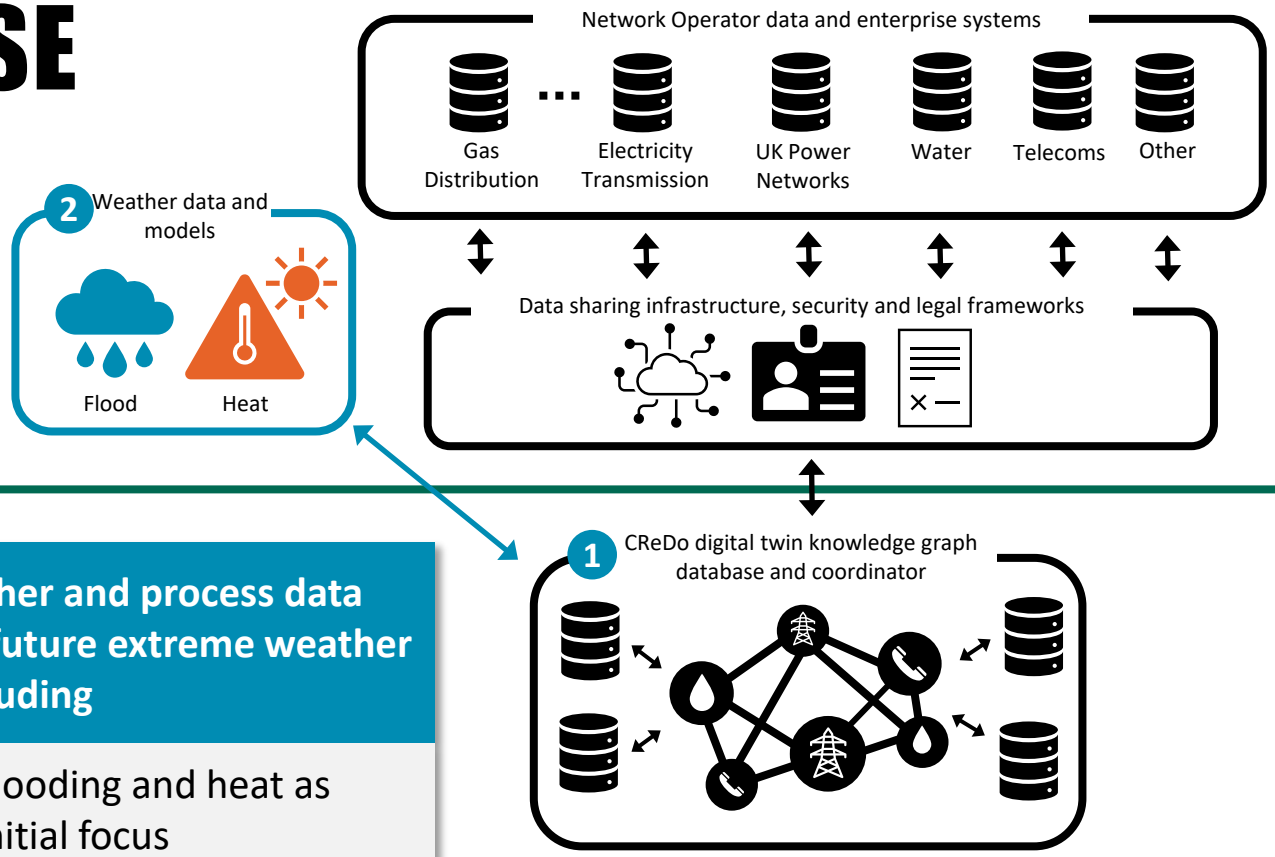


CReDo Digital Twin

1. Connect network and asset data across organisations by

- Developing secure data sharing infrastructure to link data and pass insights to user systems
- Establishing legal and trust frameworks to make sharing possible
- Using Digital Twin and Knowledge Graph technologies to coordinate and make it scalable and extensible

BETA PHASE

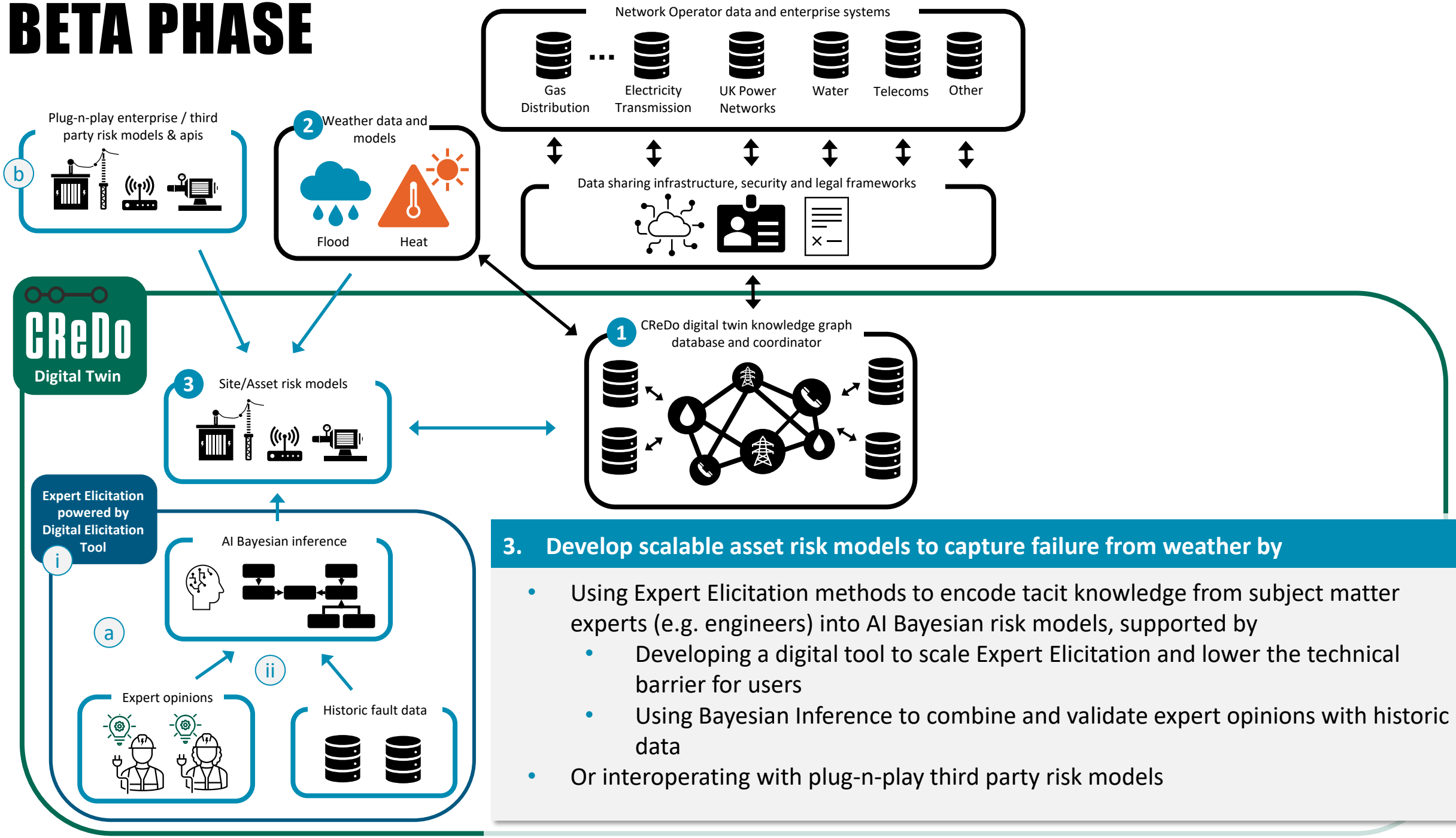


CReDo Digital Twin

2. Gather and process data on future extreme weather including

- Flooding and heat as initial focus
- Wind as extension
- Other weather and events in the longer term

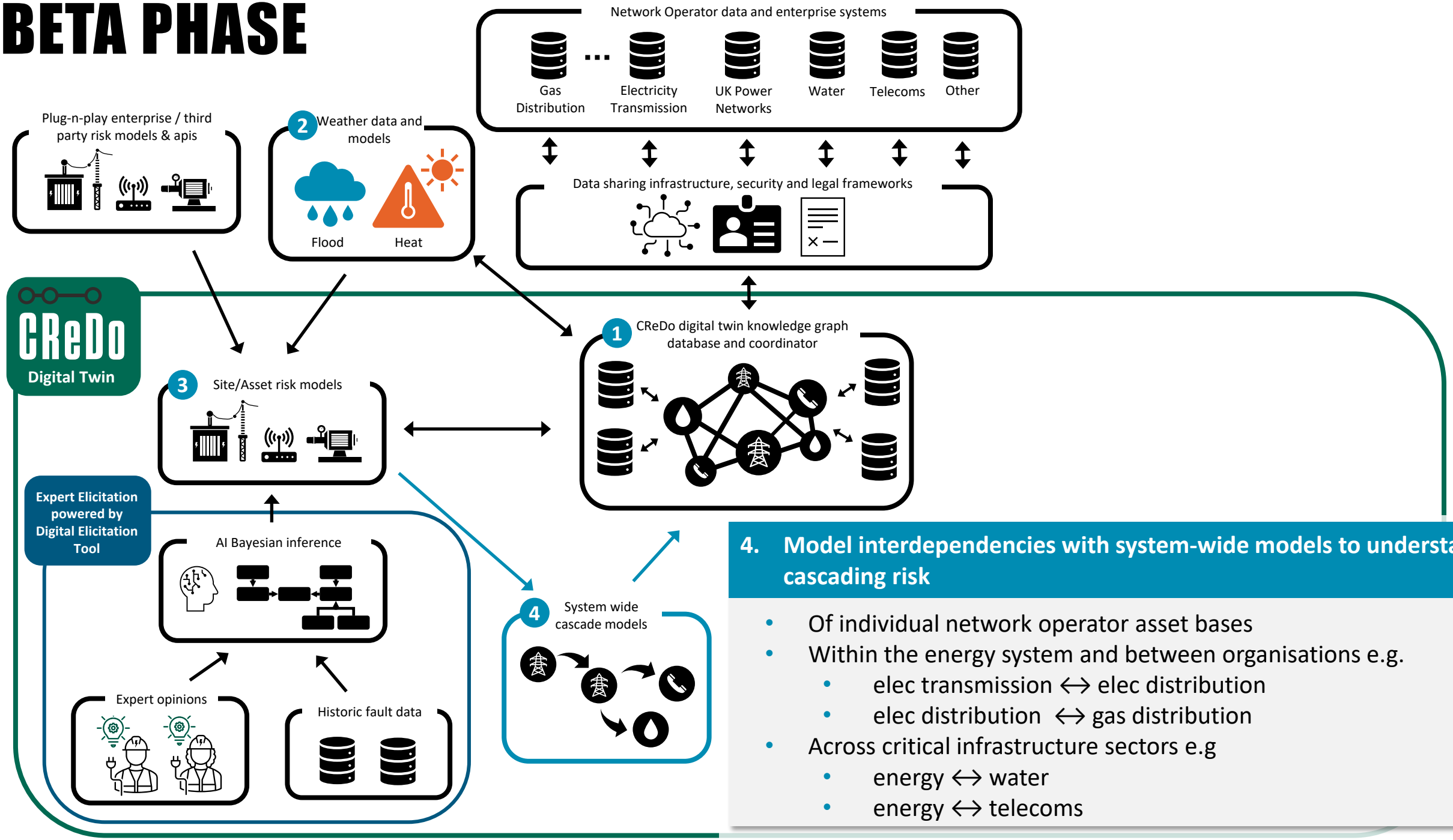
BETA PHASE



3. Develop scalable asset risk models to capture failure from weather by

- Using Expert Elicitation methods to encode tacit knowledge from subject matter experts (e.g. engineers) into AI Bayesian risk models, supported by
  - Developing a digital tool to scale Expert Elicitation and lower the technical barrier for users
  - Using Bayesian Inference to combine and validate expert opinions with historic data
- Or interoperating with plug-n-play third party risk models

BETA PHASE



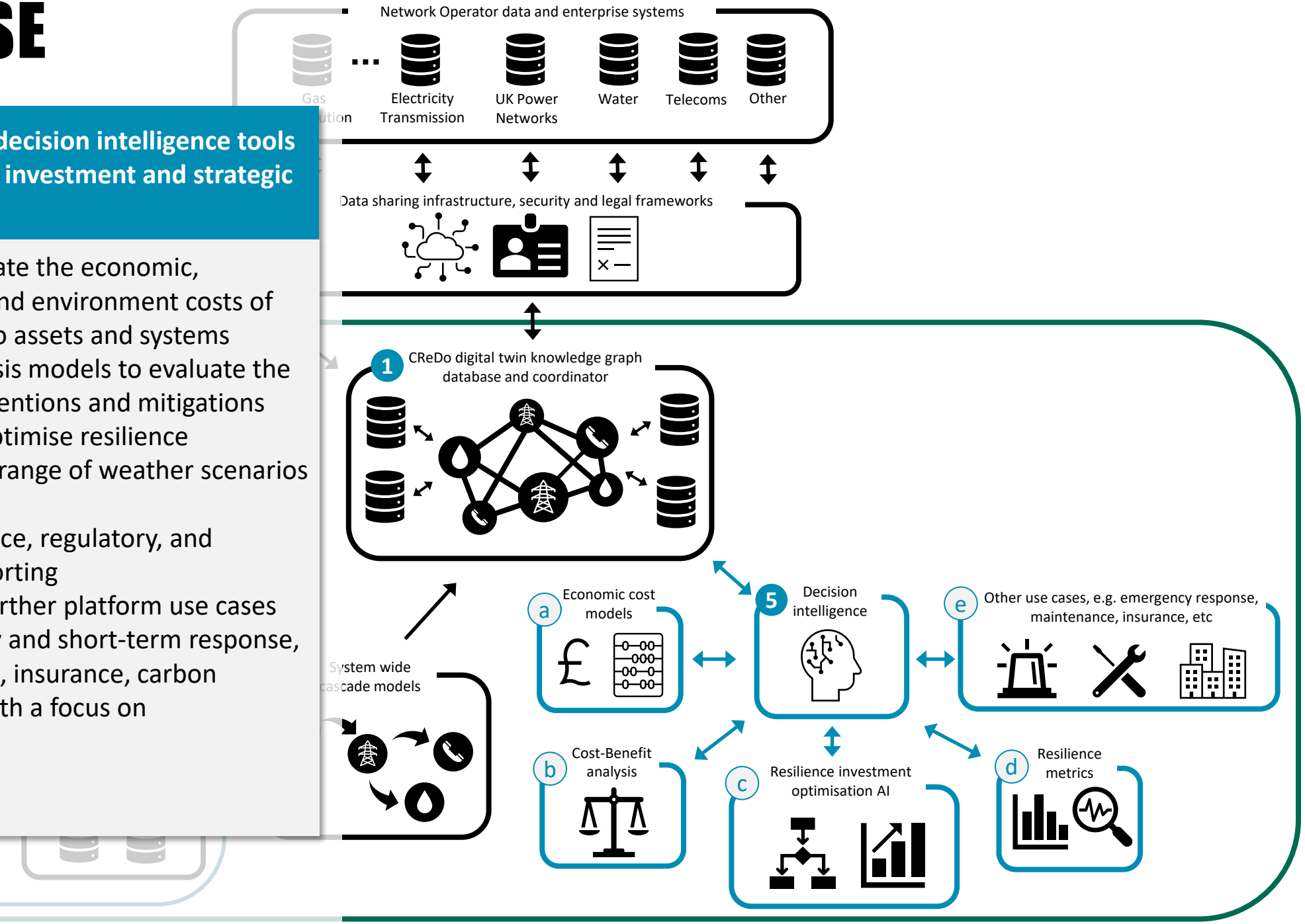
4. Model interdependencies with system-wide models to understand cascading risk

- Of individual network operator asset bases
- Within the energy system and between organisations e.g.
  - elec transmission ↔ elec distribution
  - elec distribution ↔ gas distribution
- Across critical infrastructure sectors e.g
  - energy ↔ water
  - energy ↔ telecoms

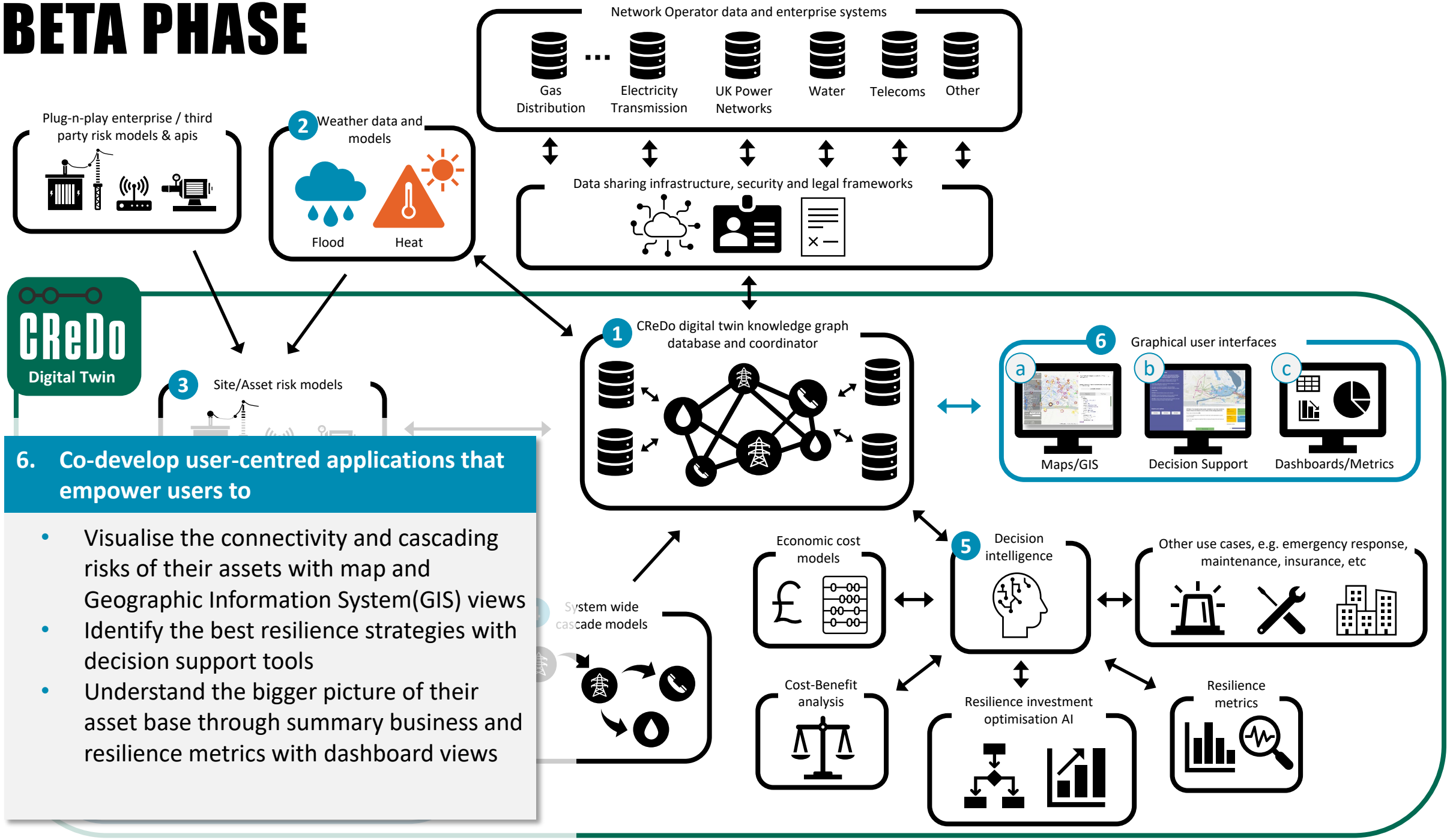
BETA PHASE

5. Co-design a suite of decision intelligence tools to support resilience investment and strategic planning including

- Cost models evaluate the economic, customer, social, and environment costs of weather impacts to assets and systems
- Cost-benefit analysis models to evaluate the net-value of interventions and mitigations
- AI algorithms to optimise resilience investment over a range of weather scenarios and time horizons
- Metrics for resilience, regulatory, and governmental reporting
- And will explore further platform use cases such as emergency and short-term response, asset maintenance, insurance, carbon accounting, etc, with a focus on interoperability



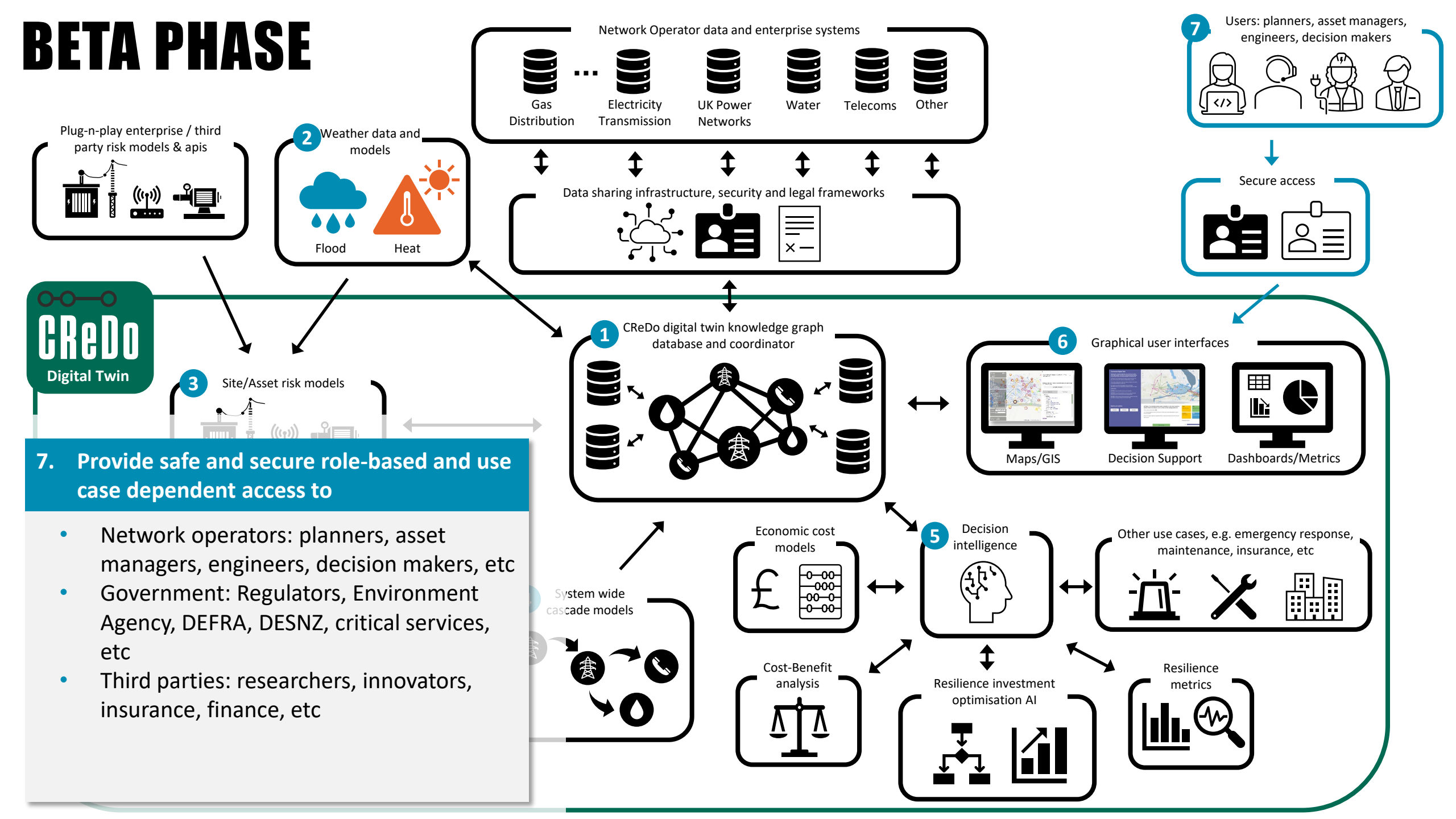
BETA PHASE



6. Co-develop user-centred applications that empower users to

- Visualise the connectivity and cascading risks of their assets with map and Geographic Information System(GIS) views
- Identify the best resilience strategies with decision support tools
- Understand the bigger picture of their asset base through summary business and resilience metrics with dashboard views

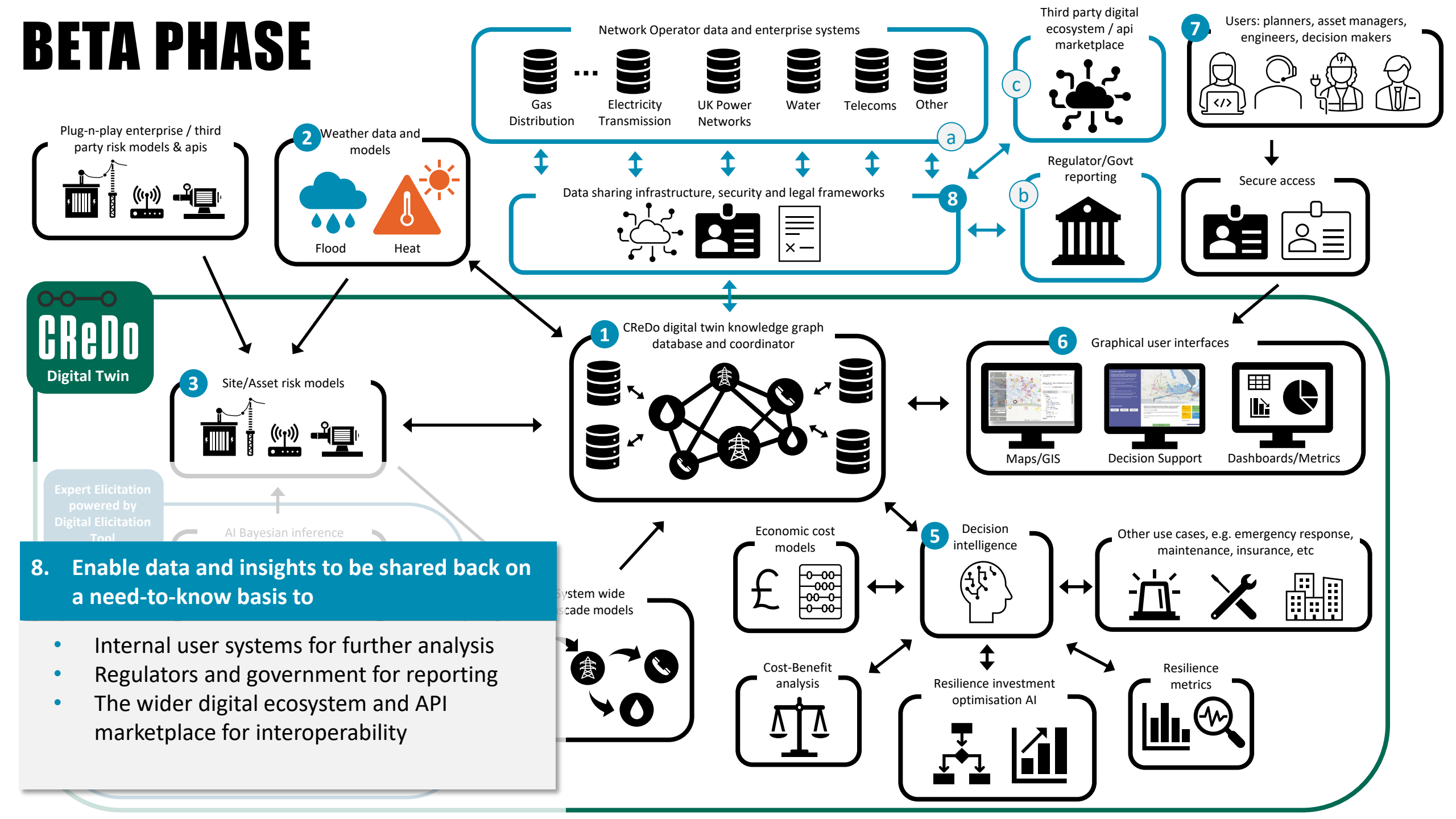
BETA PHASE



7. Provide safe and secure role-based and use case dependent access to

- Network operators: planners, asset managers, engineers, decision makers, etc
- Government: Regulators, Environment Agency, DEFRA, DESNZ, critical services, etc
- Third parties: researchers, innovators, insurance, finance, etc

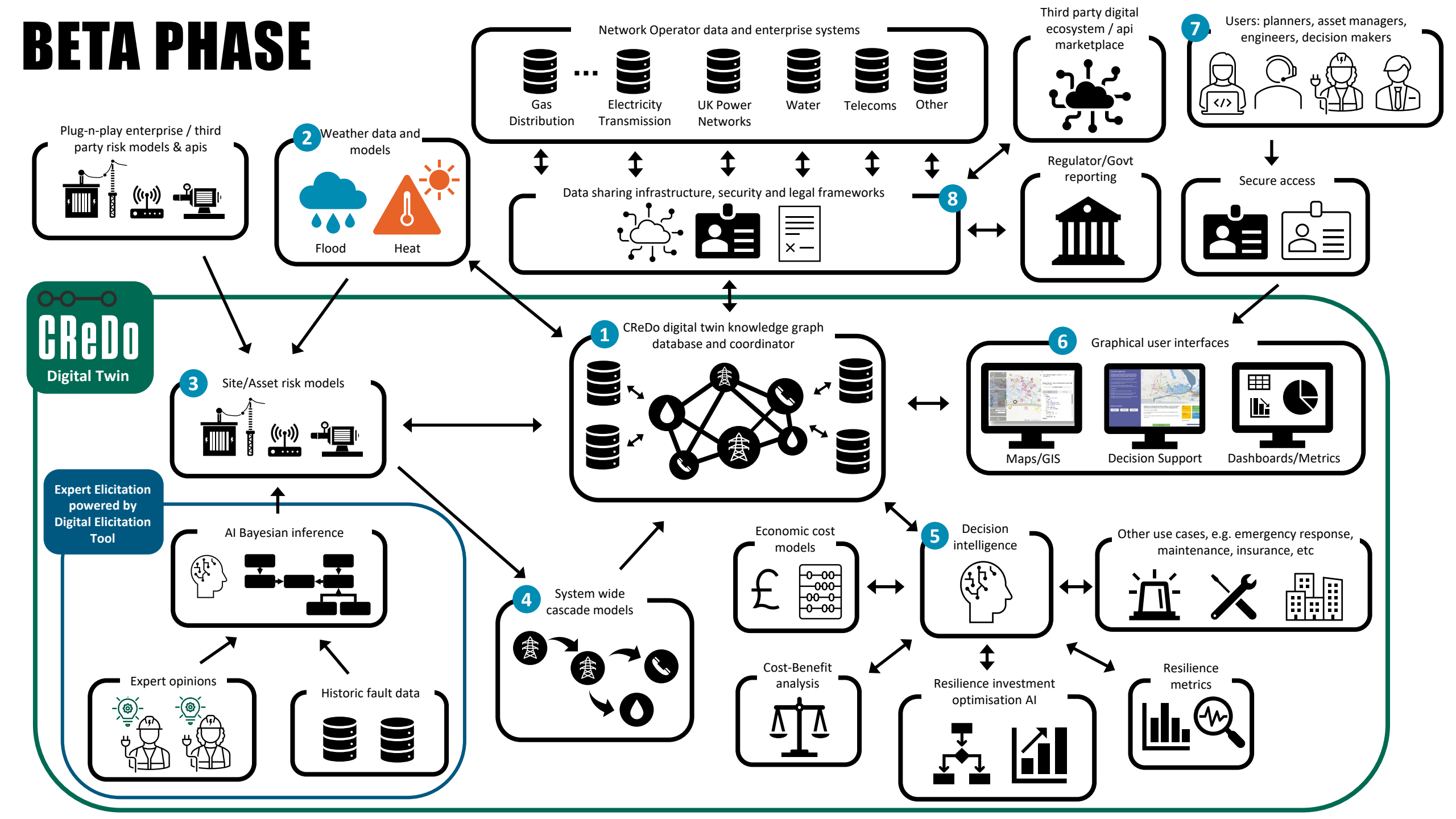
BETA PHASE



8. Enable data and insights to be shared back on a need-to-know basis to

- Internal user systems for further analysis
- Regulators and government for reporting
- The wider digital ecosystem and API marketplace for interoperability

BETA PHASE


Network Operator data and enterprise systems
Gas Distribution
Electricity Transmission
UK Power Networks
Water
Telecoms
Other
Third party digital ecosystem / api marketplace
7
Users: planners, asset managers, engineers, decision makers
Plug-n-play enterprise / third party risk models & apis
2
Weather data and models
Flood
Heat
Data sharing infrastructure, security and legal frameworks
8
Regulator/Govt reporting
Secure access
CReDo
Digital Twin
1
CReDo digital twin knowledge graph database and coordinator
6
Graphical user interfaces
Maps/GIS
Decision Support
Dashboards/Metrics
3
Site/Asset risk models
Expert Elicitation powered by Digital Elicitation Tool
AI Bayesian inference
Expert opinions
Historic fault data
4
System wide cascade models
Economic cost models
5
Decision intelligence
Other use cases, e.g. emergency response, maintenance, insurance, etc
Cost-Benefit analysis
Resilience investment optimisation AI
Resilience metrics

CReDo+ BETA PHASE

Supporting activities

- Project management, governance, and agile delivery
- Impact assessment, monitoring, and evaluation
- Route to market, commercialisation, and exploitation
- Resilience working group and advisory group
- Engagement and dissemination
- Regulatory change

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CMCL

APPENDIX

Work Package Status

WP1: PROJECT MANAGEMENT

02 October 2023 – 01 April 2024, Lead: CPC

Details

Objectives:

- Coordinate delivery of the project across all partners, ensuring progress against milestones and delivery objectives.
- Ensure transparency across all delivery and engagement work packages through agile ways of working and transparency using Jira.

Risks, Issues & Barriers:

- **Work started at risk as contract signing is still ongoing –** CPC is the main contributor to initial project tasks and has worked at risk. Other partners are working at risk in the final stages of signing. See later slide on this.
- **Risk management** - a register of risks is maintained at start of each two-week sprint.
- **Project planning** - A detailed Jira project plan has been created, including Gantt chart, dependencies, responsibility and ownership, acceptance criteria and deadlines of concurrent activities. Reviewed in fortnightly sprint planning.
- **Documentation management** - A collaborative working space has been established on UK Power Networks SharePoint
- **Budget control** - PM and each WP owner will maintain oversight on project spend. Each partner will flag discrepancies from the spend trajectory.
- **Tight timeline** - Split the work in smaller, two-week sprints for better progress monitoring. Multiple shorter weekly progress meeting to catch issues & blockers early, with transparency of work and progress easy to see on Jira.
- **Short month (December) -** Re-organised sprint structure to avoid having more than one Bank Holiday in any given sprint. Planning to avoid any deliverables last week of December
- **Partners under sourcing of staff on the project** – all partners have assured staff availability and ringfenced resources for the project.

Project Tasks, Deliverables & Milestones

Status	Description	Start	End	Comments
☑	Draft, update and maintain 2nd Level Plan	02/10/2023	30/10/2023	
☑	Kick-off meeting	02/10/2023	16/10/2023	
☑	Team onboarding	02/10/2023	16/10/2023	
☑	Project management	02/10/2023	01/04/2024	
☑	Project governance documents in place	30/10/2023	13/11/2023	
☑	Risk and Issue Management	02/10/2023	01/04/2024	
☑	Technical oversight	02/10/2023	01/04/2024	
☑	Delivery oversight	02/10/2023	01/04/2024	
☑	**D1.1: Project closure**	02/10/2023	01/04/2024	
☑	**M1.1: Project completion**	02/10/2023	01/04/2024	

Summary

●	Overall	Project delivered as per plan.
●	Time	Project delivered within planned timeline.
●	Scope	Project delivered the agreed scope.
●	Cost	Project delivered within allocated budget.

WP2: UK POWER NETWORKS DATA, ASSET AND TESTING SUPPORT

02 October 2023 – 28 March 2024, Lead: UK Power Networks

Details

Objectives:

- Support in general coordination of delivery of the project and direction of non-technical aspects of project and reporting in accordance with funder guidelines.
- Ensure access to data and/or expert advice in the areas of corporate data, asset/process management and operation and project output testing.
- Provide support via introductions, organisation, content creation and/or delivery of strategic engagement sessions.

Risks, Issues & Barriers:

- **Availability of UK Power Networks' stakeholders** - PM to support in accessing stakeholders. Strong level of support from senior management achieved during Discovery Phase.
- **Availability of UK Power Networks' data** – phased approach to requests, data agreements covered in collaboration agreement (signing in progress). Discovery phase identified data shortlist.

Project Tasks, Deliverables & Milestones

Status	Description	Start	End	Comments
☑	Project management	02/10/2023	18/03/2024	
☑	Data support	02/10/2023	18/03/2023	
☑	Asset support	16/10/2023	18/03/2023	
☑	Testing support	13/11/2023	18/03/2014	
☑	Strategic engagement support	13/11/2023	18/03/2014	
☑	**D2.1: UK Power Networks engagement and data gathering**	18/03/2024	28/03/2024	
☑	**M2.1: UK Power Networks engagement and data gathering**	18/03/2024	28/03/2024	

Summary

Overall	Project delivered as per plan.
Time	Project delivered within planned timeline.
Scope	Project delivered the agreed scope.
Cost	Project delivered within allocated budget.

WP3: NG ESO ASSET AND TESTING SUPPORT

27 November 2023 – 28 March 2024, Lead: NG ESO

Details

Objectives:

- Support in general coordination of delivery of the project and direction of non-technical aspects of project and reporting in accordance with funder guidelines.
- Ensure access to expert advice in the areas of corporate data, asset/process management and operation and project output testing.

Risks, Issues & Barriers:

- **Availability of NG ESO' stakeholders** - UK Power Networks PM enabled the organisation of four workshops with NG ESO stakeholders throughout the project.
- **Demonstrator testing delays** – plan enough time allocation for testing.
- **Partner under sourcing of staff on the project –** workshops were attended by the right stakeholders to gain appropriate insight and collaborative feedback.

Project Tasks, Deliverables & Milestones

Status	Description	Start	End	Comments
☑	Project management	27/11/2023	18/03/2024	Contract
☑	Asset support	25/12/2023	18/03/2024	Contract
☑	Testing support	22/01/2024	18/03/2024	Contract
☑	D3.1: NG ESO engagement of user research, design validation and prototype testing	18/03/2024	28/03/2024	Contract
☑	M3.1: NG ESO engagement of user research, design validation and prototype testing	18/03/2024	28/03/2024	Contract

Summary

●	Overall	Project delivered as per plan.
●	Time	Project delivered within planned timeline.
●	Scope	Project delivered the agreed scope.
●	Cost	Project delivered within allocated budget.

WP4: CReDo ASSET AND SYSTEM MODELLING

02 October 2023 – 18 March 2024, Lead: CPC

Details

Objectives:

- Obtain preliminary versions of asset, network and climate data to be handed over to leads on WP5 and WP6 to enable early start of those streams.
- Process subject matter expert knowledge into a preliminary modelling framework for both assets and system cascade. This is to be handed over to leads on WP5 and WP6 to enable early start of those streams.
- To obtain final versions of above items and hand over to WP5 and WP6 leads to enable latest part of their development work.

Risks, Issues & Barriers:

- **Appropriate climate data not available -** Exploration of raw climate data (UKCP18) revealed a lack of data around the higher part of the temperature range of interest (30-45 deg. C). The elicitation process uncovered a collection of heat-derived risks, which enabled synthetic data to be used to represent 'heat wave events' instead and obtain model outputs for demonstration purposes.
- **Challenges with extreme heat asset modelling -** Work in Alpha Phase demonstrated there are a collection of heat derived risks which can be modelled with elicitation. The methodology is therefore relevant and applicable. Some other risks, such as those related to 'wear and tear', require further investigation to understand if elicitation is applicable. Future interopability of CReDo would enable other risks to still be represented through other applicable methods of modelling.

Project Tasks, Deliverables & Milestones

Status	Description	Start	End	Comments
☑	Preliminary asset and network data provision and processing	02/10/2023	30/10/2023	
☑	Preliminary climate data provision and processing	02/10/2023	30/10/2023	
☑	Preliminary structural and probability expert elicitation interviews	16/10/2023	13/11/2023	
☑	Preliminary asset and system modelling	16/10/2023	27/11/2023	
☑	**D4.1: Preliminary asset, system, and climate data and models**	02/10/2023	27/11/2023	
☑	**M4.1: Preliminary phase**	02/10/2023	27/11/2023	
☑	Asset and network data provision and processing	27/11/2023	25/12/2023	
☑	Climate data provision and processing	25/12/2023	22/01/2024	
☑	Structural and probability expert elicitation interviews	27/11/2023	22/01/2024	
☑	Asset and system modelling	22/01/2024	04/03/2024	
☑	CReDo electricity generation discovery (with NG ESO)	25/12/2023	19/02/2024	
☑	**D4.2: Asset, system, and climate data and models**	27/11/2023	18/03/2024	
☑	**M4.2: Full phase**	27/11/2023	18/03/2024	

Summary

●	Overall	Project delivered as per plan.
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●	Scope	Project delivered the agreed scope.
●	Cost	Project delivered within allocated budget.

WP5: CReDo EXTREME HEAT PROTOTYPE

27 November 2023 – 28 March 2024, Lead: CMCL

Details

Objectives:

- Update core CReDo technology to accommodate new input data, modelling outputs and other supporting data needed to develop the extreme heat use case for the energy sector.
- Loading new asset and weather event data into the CReDo prototype.
- Integrate extreme heat failure models into the prototype and update visualisation to show relevant insights.
- Run the prototype for an extreme heat scenario and provide a demo of new functionality.

Risks, Issues & Barriers:

- **Late delivery of sample asset and hazard data (describing extreme heat)** - Delivery of required information was split to include a preliminary phase to ensure timely delivery of the minimum information necessary to allow dependent activities to commence in a timely manner. The other asset and hazard data was collected through elicitation interviews.

Project Tasks, Deliverables & Milestones

Status	Description	Start	End	Comments
☑	Update ontology	27/11/2023	08/01/2024	
☑	**D5.1: Extension of CReDo ontologies for asset and hazard data for extreme heat scenario**	08/01/2024	22/01/2024	
☑	**M5.1: Extension of CReDo ontologies for asset and hazard data for extreme heat scenario**	08/01/2024	22/01/2024	
☑	Load asset and hazard (i.e. extreme heat) data into CReDo prototype	11/12/2023	22/01/2024	
☑	Integrate preliminary heat failure models into CReDo prototype	11/12/2023	22/01/2024	
☑	Integrate heat failure models into CReDo prototype	22/01/2024	19/02/2024	
☑	Visualisation of hazard and asset data for extreme heat scenario in CReDo prototype	22/01/2024	18/03/2024	
☑	Run demonstrator of CReDo prototype for extreme heat scenario	05/02/2024	28/02/2024	Demo shown at the Plenary session of 29/02/2024 and during sprint demos
☑	**D5.2: CReDo extreme heat demo**	18/03/2024	28/03/2024	
☑	**M5.2: CReDo extreme heat demo**	18/03/2024	28/03/2024	

Summary

●	Overall	Project delivered as per plan.
●	Time	Project delivered within planned timeline.
●	Scope	Project delivered the agreed scope.
●	Cost	Project delivered within allocated budget.

WP6: DIGITAL ELICITATION TOOL PROTOTYPE

27 November 2023 – 18 March 2024, Lead: STFC

Details

Objectives:

- Wireframe digital elicitation prototype concept for initial stakeholder engagement to obtain key feedback for further design.
- Prototype key components of digital elicitation tool (i.e. the model and the questionnaire builder features)
- Put in place preliminary version of required infrastructure between key components to support early prototype of the tool.
- Deliver user testing of prototype and gather/process feedback for future development cycles.
- Deliver and demonstrate capabilities of digital elicitation tool prototype.

Risks, Issues & Barriers:

- **If the key resources were not available for elicitation interviews and consultation within the required time, then the relevant insights would not have been created and the quality of the conclusions and feasibility for Beta Phase would have been reduced** - Planning and support led to engagements for model building including stakeholders from across UK Power Networks. Further clarification on conflicting insights from prior interviews was achieved. Post the first session testing the DET prototype with UK Power Networks stakeholders, the action was taken to utilise remaining sessions to further develop the potential user base understanding of the core purpose and functionality of CReDo and the DET. Remaining prototype testing was conducted with an in-house elicitation expert.

Project Tasks, Deliverables & Milestones

Status	Description	Start	End	Comments
☑	Wireframe for stakeholder engagement	27/11/2023	08/01/2024	Work was done at risk
☑	Model and questionnaire builder prototypes	11/12/2023	05/02/2024	
☑	Infrastructure / loose couplings between builders	05/02/2024	04/03/2024	
☑	Iterative user testing	08/01/2023	18/03/2024	
☑	**D6.1: Digital elicitation tool prototype**	04/03/2024	18/03/2024	
☑	**M6.1: Demonstrate prototype tool capabilities**	04/03/2024	18/03/2024	

Summary

●	Overall	Project delivered as per plan.
●	Time	Project delivered within planned timeline.
●	Scope	Project delivered the agreed scope.
●	Cost	Project delivered within allocated budget.

WP7: BUSINESS CASE AND COST BENEFIT ANALYSIS

27 November 2023 – 28 March 2024, Lead: CPC

Details

Objectives:

- Build a logic model/theory of change output for the CReDo extreme heat use case extension to illustrate key steps in successful long-term development.
- Engage with UK Power Networks to obtain necessary data, information and feedback for the development of the business case and analysis.
- Populate data, assumptions and information to underlying model and perform the cost benefit analysis.
- Write business case and cost benefit analysis.

Risks, Issues & Barriers:

- **Lack of data publicly available to quantify the scale of how extreme heat benefits compared to flooding benefits as part of the Cost Benefit Analysis (CBA) -** Desk research (academic journals, industry reports, etc.) and data gained from interviews were applied to the CBA. Sensitivity analysis was applied to test how sensitive results were to changes in input, with methodology and assumptions stated in the model and supporting narrative
- **CBA template supplied by UKRI for Beta Phase was issued at the end of Feb, followed by an unexpected update to the template on 13 March. This required a material rework of the business case and CBA undertaken in this WP** – A standards-based approach was initially taken by reviewing the CBA approach in UK Power Networks, and green book standards. With the template update being issued two weeks before the end of the project, there was a significant risk WP7's review process would be delayed. An agreement was therefore reached that the model could be transferred to the new template in a later phase.

Project Tasks, Deliverables & Milestones

Status	Description	Start	End	Comments
☑	Logic model / theory of change	27/11/2023	25/12/2023	
☑	Data gathering & engagement	11/12/2023	22/01/2024	
☑	Populate model with data	08/01/2024	05/02/2024	
☑	Cost benefit analysis	22/01/2024	19/02/2024	Template changed 13/03/2024
☑	Write Business Case	05/02/2024	18/03/2024	
☑	QA and Sense checking	19/02/2024	18/03/2024	
☑	**D7.1: Cost Benefit analysis and business case**	18/03/2024	28/03/2024	
☑	**M7.1: Cost Benefit Analysis and Business Case**	18/03/2024	28/03/2024	

Summary

●	Overall	Project delivered as per plan.
●	Time	Project delivered within planned timeline.
●	Scope	Project delivered the agreed scope.
●	Cost	Project delivered within allocated budget.

WP8: ENGAGEMENT AND DISSEMINATION

30 October 2023 – 28 March 2024, Lead: CPC / Sarah H

Details

Objectives:

- Validate demand and scaling assumptions via input from strategic stakeholders and compare our approach to others being developed internationally.
- Set up a data sharing for climate resilience and robustness groups key stakeholders from the energy sector.
- General dissemination of outputs of both Ofgem funded phases.
- Obtain a good understanding of the requirements for cross-sector data sharing from a legal point of view as an enabler for further work in the Beta Phase.
- Produce a project summary report.
- Deliver a workshop to showcase key aspect of the project to critical stakeholders.

Risks, Issues & Barriers:

- **Limited access to stakeholders** – CReDo is an ongoing programme with significant momentum and interest across stakeholder groups. UK Power Networks and National Grid ESO enable good coverage of wider energy sector stakeholders. Innovate UK have offered to facilitate introductions to other projects.

Project Tasks, Deliverables & Milestones

Status	Description	Start	End	Comments
☑	Strategic stakeholder engagement across sector to validate demand and scaling assumptions	30/10/2023	19/02/2024	
☑	Set up data sharing for climate resilience and robustness working group	27/11/2023	22/01/2024	
☑	Dissemination of CReDo+ discovery and alpha lessons and findings across sectors	19/02/2024	01/04/2024	
☑	**D8.1: Project report**	30/10/2023	28/03/2024	
☑	**D8.2: Workshop to showcase project with key representatives**	19/02/2024	12/03/2024	Initial delivery date of 04/03/2024 amended
☑	**M1: Engagement and dissemination**	30/10/2023	28/03/2024	
☑	**M2: Support on engagement and dissemination across sectors**	30/10/2023	28/03/2024	
☑				

Summary

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●	Cost	Project delivered within allocated budget.