The Voice of the Networks

Energy Networks Association

Open Networks Project

Whole System cost-benefit analysis

Phase 1 report

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Document Control

Version Control

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1.0	1 April 2020	Product 1 team	Released for sign-off to WS4 meeting
1.1	7 April 2020	Product 1 team	Typographical error in executive summary corrected. Table for Use Case 5 corrected.
1.2	9 April 2020	Product 1 team	Minor updates post WS4 meeting. Released for sign-off to Steering Group and Gas Futures Group.

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Executive Summary

The UK's energy system is going through revolution to deliver a net zero network that is affordable, reliable and carbon neutral. This requires whole system solutions which must be achieved through informed decision making. Cost-benefit analysis (CBA) is a key tool in supporting those decisions to ensure they are optimal for consumers, the public, the environment and the industry as a whole.

There are currently sophisticated CBA tools within sectors but there is a gap across sectors and industries. This gap has been recognised and to address it, the ENA Open Networks project have commissioned a piece of work by a subgroup with representation across gas and electricity, transmission, distribution and system operation.

The objective is to develop Whole System CBAs to support the move to an energy network which is best value for consumers. The project is planned over three phases and this report summarises phase 1. It details the process gone through, the stakeholders engaged and the recommendations to move this forward.

The key output is five CBA use cases. They are explored in detail in the document and are summarised in the table below.

Use case	Description	Value (including carbon)	Difficulty to implement
Asset replacement	When significant investment is required to manage asset health and risk, are there alternative cross sector solutions to asset replacement	£100m's	H – needs regulatory change
Investment planning	If system reinforcement is required for new connections, what is the optimum energy solutions for the consumer	£1,000m's	H – needs regulatory change
Embedded generation	How do we get best value from the low carbon energy sources available	£10m's	M – will need appropriate incentives for generators
Local Authority Planning	LAs are producing local energy strategies and could benefit from a tool to inform these plans	£100m's	L – there are existing tools and processes in place
Strategic Planning	Government energy and policy and funding is critical and could be supported by a whole system CBA	£1,000m's	M – there are numerous factors and trade-offs that need to be considered

Table 1 – summary of use cases

The recommendation is to proceed with the Local Authority Planning CBA use case with a stage gate following its completion. At this stage gate, the decision to proceed with further CBAs will be made. The trial will consider and develop the CBA model and methodology, cost, benefits and value, the stakeholders, the users and challenges in implementing. The learning from developing this CBA will significantly benefit development of the other use cases.

If approved, the trial will commence in May and conclude by the end of August, although this would be kept under review. The phase 2 report would be ready for sign-off in October. Monthly updates would be provided to WS4.

Report Body

Part 1 - Background

Introduction
Product 1 was recommended in the Workstream 4 (WS4) Final 2019 Report[1]. The following background was given:

It is widely recognised that in order to enable whole system decision making a whole system cost-benefit analysis (CBA) is one of the fundamental requirements. This is necessary to consider whether a solution is the optimal outcome on a whole system basis rather than what is generally considered to date which is using a sector specific CBA with fairly narrow parameters.

Whole system solutions will be crucial if the UK is to meet its net-zero targets. As noted by the Committee on Climate Change[2]:

The net-zero challenge must be embedded and integrated across all departments, at all levels of Government and in all major decisions that impact on emissions. It must also be integrated with businesses and society at large. Since many of the solutions cut across systems (e.g. hydrogen has a role in electricity generation, transportation, industry and heating), fully integrated policy, regulatory design and implementation is crucial.

Scope
The product has potential for three phrases:

- Phase 1: develop recommendations for broad principles, key elements and scope to be applied to a whole system CBA and the circumstances in which a whole system verses sector specific model should be used.
- Phase 2: more detailed specification and parameters to be defined, building on the broad principles, scope and application set out in phase 1. Also ensuring that the detail is complementary to the sector specific CBA model(s).
- Phase 3: build and trial using case studies of a CBA model[3].

Team members
The following participants supported Product 1:

Name	Company
David Bowman	National Grid Electricity System Operator
Jingchao Deng	National Grid Electricity System Operator
Ian Dunstan	Wales & West Utilities
Alasdair Gaw	Scottish Power Energy Networks (Distribution)
Christos Kaloudas	Electricity North West
Ryan Kavanagh	Western Power Distribution
Dean Pearson	Northern Gas Networks
Michael Rieley	SSE
Drew Sambridge	Cadent
Chris Thompson	National Grid Gas

Table 2 – WS4 P1 group members

Definition of whole system

[1] Energy Networks Association: Open Networks project Workstream 4 Whole Energy System Final 2019 Report https://www.energynetworks.org/assets/files/ONP-WS4-Final%20Report-PUBLISHED.pdf
[2] Committee on Climate Change: Net-zero – the UK's contribution to stopping global warming (page 272) https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf
[3] In line with the recommendations, we propose trialling one use case as part of phase 2.

Product 1 adopted the definition of "whole system" given in the WS4 Final 2019 Report:

"Whole system" was interpreted as interactions between the gas and electricity networks. Broader whole system interactions such as transport, water, waste were noted and it was agreed that these would be considered but not as core focus.

The definition of whole system is used as one of the three tests of when a whole system CBA should be used. This is discussed in a later section.

Vision

The following principles should guide the development of a whole system CBA:

- A whole system CBA should **evaluate options to help achieve net-zero**. This includes assessing the wider societal benefits of different options, protecting current and future consumers and developing a consistent approach to appraise options[4].
- **Consumer benefit should be at the heart of decision making**. A whole system CBA should capture the varied ways benefits can be delivered. The whole system CBA process should be transparent and understood both inside and outside of regulated energy networks. Key stakeholders should support it, including BEIS, Ofgem, the energy networks, other industry participants and consumer groups such as Citizens Advice.
- The whole system CBA should be used to **articulate the benefits the energy industry delivers**. With growing political and regulatory scrutiny of costs and activities, a whole system CBA can be a key tool to demonstrate that energy networks are acting in the best interests of consumers.
- **Help deliver a secure network at optimal value for money to consumers**. This includes considering the needs of both present and future consumers, and wider society.
- Support **objective, technology neutral and transparent decision making.** It will enable costs and value to be drawn out, explicit for all to see.
- The whole system CBA should **one element of a decision-making toolkit.** In any investment decision, several factors need to be considered, some of which may not be suitable for a CBA.
- Consideration should be given to the **sharing of the surplus value** generated from allowing another company to provide a more net beneficial solution.

Review of current CBAs

A variety of CBA that are used across the industry were considered. This helped identify where there may be a role for a whole system CBA and potential challenges to its development or implementation. In addition, to consider best practice for a whole system CBA, including elements that may be better suited to sector specific CBA.

RIIO-2

The electricity transmission, gas transmission and gas distribution networks, and the electricity system operator (ESO), undertook CBA as part of their RIIO-2 submissions. The methodologies and models[5] used were set by Ofgem, following development with stakeholders in Ofgem-led Costs & Outputs working groups[6]. The network companies have each produced a consumer value proposition (CVP) to highlight the additional ways their plans deliver value to customers and wider society. The current CVP assessment varies between companies and there is an ongoing project looking to consider a homogeneous approach. The recommendations from this could feed into a whole system CBA. The ESO produced a cost-benefit analysis report, using a bespoke methodology and model that was adapted from electricity transmission. The RIIO-2 CBA models are grounded in the HM Treasury Green Book. This should continue, including any revisions to this provided by the government.

On the electricity transmission side, the group noted that, as opposed to RIIO-T1, CBAs have moved away from purely "constraint savings versus investment" decisions to consider wider aspects such as carbon savings. The gas transmission and distribution network CBAs also place a large focus on

[4] It is possible that the definition of "whole system" as proposed by the WS4 2019 final report may need to be amended to reflect this

[5] https://www.ofgem.gov.uk/publications-and-updates/riio-2-final-data-templates-and-associated-instructions-and-guidance

[6] https://www.ofgem.gov.uk/network-regulation-riio-model/network-price-controls-2021-riio-2/riio-2-events-seminars-and-working-groups

safety, including risk to life, consistent with their activities. The ESO CBA categories benefit into 5 areas[7] – this approach is also used by Ofgem and is the framework used by WS4.

The wider-ranging focus of more recent CBAs should be applied to a whole-system CBA. The current sector-specific methodologies and models are tools that, suitably adapted, should form the basis of the whole system CBA (in terms of data population and the "mechanics" of the CBA), rather than creating new tools. Upcoming regulated network price controls, including RIIO-ED2, the two-year ESO funding cycle and RIIO-3 may provide the first opportunities to deploy a whole system CBA alongside sector-specific ones. Given the RIIO ED-2 timescales, it may not be possible to fully embed a whole system CBA into the regulatory framework. However, it provides an excellent opportunity for a trial and it is recommended that this is considered in Phase 2.

In line with the published methodologies, decisions are made by considering three elements: the CBA, stakeholder feedback and engineering/technical justification. There is no weighting of these. A similar approach should be taken in the use of a whole system CBA, and this forms part of the Vision.

Network Options Assessment (NOA)
The *NOA*[8] is an ESO-run annual process that helps develop an efficient, economic and coordinated electricity transmission system. Building on the *Future Energy Scenarios*[9] and *Electricity Ten Year Statement*[10] the *NOA* runs a cost-benefit analysis of transmission network solutions (reinforcements) to transmission network challenges on a least-worst regrets basis to determine optimal levels of investment to manage constraints. The *NOA* is also used to indicate the optimum level of interconnection to other European electricity grids to maximise socio-economic welfare, based on market-driven analysis.

Strategic Wider Works (SWW)
An extension of the *NOA* is that it can also identify which recommended reinforcements meet the SWW criteria[11] such that a SWW Needs Case can be initiated by the TOs to develop the reinforcements further. The ESO undertakes the Needs Case CBA to inform the most optimal SWW option to be delivered.

Connection and Infrastructure Options Note (CION)
The ESO also runs the Connection and Infrastructure Options Note (CION) Process. This is a CBA for offshore developments to determine the best location for the onshore connection to minimise costs. It considers both developer and network costs as well as impact on constraint costs by the connections.

It should be noted that the *NOA* process identifies the system needs and provides the industry the recommendations that should be followed to maximise consumer benefits, but what and when to deliver those investments are still at the TO's discretion. However, the SWW and CION CBAs will directly influence their process outputs.

As part of its RIIO-2 proposals[12] the ESO is proposing to introduce commercial solutions from third parties (i.e. not ETOs) into the NOA through its Pathfinders and the wider Network Development Roadmap[13]. The group noted that a whole system CBA could be used to improve the decision making around which commercial solution to use. This forms one of the use cases listed below.

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[7] Improved safety and reliability; lower bills than would otherwise be the case; reduced environmental damage; improved quality of service; benefits for society as a whole

[8] https://www.nationalgrideso.com/publications/network-options-assessment-noa

[9] http://fes.nationalgrid.com/

[10] https://www.nationalgrideso.com/publications/electricity-ten-year-statement-etys

[11] https://www.ofgem.gov.uk/electricity/transmission-networks/critical-investments/strategic-wider-works

[12] https://www.nationalgrideso.com/about-us/business-planning-riio/riio-2-final-business-plan

[13] https://www.nationalgrideso.com/publications/network-options-assessment-noa/network-development-roadmap

NARMs / Monetised Risk
Network Asset Resilience Metrics (NARMs) models, formally known as Network Outputs Measures (NOMs), are an established methodology used by gas and electricity networks to report on the monetised risk of their asset populations over time and following interventions. They are based on common probabilistic models which estimate the likelihood and consequences of asset failures given asset specific parameters, condition and age data. These form the basis of RIIO-2 CBAs in network Investment Decision Packs. These could be a key part of any whole system CBA if the different models can be improved and reconciled to allow trade-offs in risk between gas and electricity assets over time.

Other CBAs
CBA is used in a range of bespoke cases across the industry. This can include:

- Assessing the feasibility of different energy mixes for local areas, for example the Pathfinder[14] projects by Wales & West Utilities.
- Supporting re-openers for asset health replacement decisions, for example National Grid's Feeder 9 project[15]

Similar cases to those listed above provide ideal opportunities for a whole system CBA. These are developed further in the use cases below.

Current gas and electricity interactions
To help develop potential use cases for a whole system CBA, the group looked at current interaction between gas and electricity.

Electricity generation
Gas is currently used to generate around two-fifths of the UK's electricity[16]. Being a flexible resource, it is well-suited to use alongside renewables. As a fossil-fuel however, it has a significant carbon content. A whole system CBA could be used to assess future generation mixes in an area (locally, regionally or nationally). This could factor in the benefits of flexibility against the carbon price. This is explored in the use cases below. The group considered whether a whole system CBA could be applied to joint outage planning, for example optimising maintenance across a gas network, power station and electricity network. However, it was decided that this was better managed through reviewing existing processes, including improved coordination.

Excess generation and constraint management
Electricity is used in electrolysis to produce hydrogen from water. Although electricity intensive, it provides an opportunity for surplus renewable electricity to be used when it may otherwise be constrained. This could lead to significant cost and carbon savings for consumers. Hydrogen could then be transported for use in heating and cooking, potentially through existing gas assets. There is a clear use for a whole system CBA here in. For example, a hydrogen plant could be used as a commercial solution in NOA (or *NOA*-type assessment). The current *NOA* process does not consider the whole system value of commercial solutions, only that they represent a potential constraint saving.

Heating
Less than 5% of energy used for heating homes and buildings come from low-carbon sources[17]. To meet net-zero, significant process on the decarbonisation of heat is therefore required. These could include hydrogen (if low-carbon electricity is used for electrolysis and carbon capture and storage is used when producing hydrogen from natural gas) or electric heat pumps (which would also require low-carbon electricity). This needs to be balanced against the cost of converting assets, either to enable hydrogen transportation or install electric heat pumps, and consideration of whether there would be sufficient capacity on the electricity network to cover peak heating demand. There is scope for a whole system CBA to be used – if for example a gas pipe feeding a town was reaching the end

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[14] https://www.wwutilities.co.uk/media/2661/2050-energy-pathfinder-short-paper.pdf

[15] https://www.ofgem.gov.uk/ofgem-publications/133328

[16] BEIS: Digest of UK Energy statistics 5.3 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/826550/DUKES_5.3.xls

[17] Committee on Climate Change: Net-zero – the UK's contribution to stopping global warming (page 139) https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

of asset life, consideration could be given to the merits of a like-for-like replacement against electrifying a town. This is explored in the **Use Case 1** below.

Transport
Options for decarbonising transport include bio gas, hydrogen and electric vehicles. Transport currently produces approximately one-third of the UK's carbon emissions. While most sectors have reduced emissions over the last 30 years, there has been only a limited reduction in transport emissions (down by 3% on 1990 levels. Some of the key obstacles to phasing out conventional fossil fuel vehicles include consumer confidence in new technology, access to refuelling infrastructure, disruption to daily routines and cost. A whole system CBA would allow for a strategic national assessment of the various technologies and how they impact on energy networks. We have considered this in Use Cases 4 and 5 below.

Challenges to whole system interactions
The above interactions also highlighted a number of challenges, both to the interactions themselves and on the use cases for a whole system CBA. These are discussed further in a later section.

Part 2 – Use cases

The three tests for a whole system CBA
Three conditions should be met to determine whether a whole system CBA is appropriate.

1. **Are there whole system interactions, or is there potential for it?** If the only realistic options are within fuel or within an individual sector (eg electricity transmission) an appropriate sector-specific CBA should be used.
2. **Could a whole system CBA drive you to make a different decision?** A whole-system CBA needs to be carried out in good-faith with the genuine aim of considering and accepting a range of options. As we discuss below, regulatory changes may be needed to encourage this behaviour. The whole system options considered need to be plausible, but there is also likely to be a de minimis value. Phase 2 and 3 should be used to explore this.
3. **Is a whole system CBA reasonable?** CBA is complex. It can be difficult to estimate costs and benefits. There are limits on the number of factors that can reasonable be considered. A whole system CBA needs to be proportionate, transparent and understandable. Especially at first, this may limit some of the use cases. Phases 2 and 3 should be used to trial whole system CBAs in small, targeted areas.

Use cases
Several use cases for a whole system CBA have been identified. These are summarised below. For each one we have provided:

- Mock "exam-question(s)" that the whole system CBA could try to answer (for further context)
- A commentary of the use case
- The inputs and outputs to and from the whole system CBA, including the costs and benefits.
- The counterfactual
- Users and other stakeholders
- An indication of the order of magnitude of potential benefits
- An indication of the practicalities of conducting a whole system CBA.

It should be noted that these use cases are currently presented at a high-level, and there has been no attempt to source any data or run any indicative calculations. Subject to approval, this should be done through phases 2 and 3. For clarity, a tangible, specific example has been given with each use case, but they are by no means restricted to the example given.

Use Case 1	Asset replacement
Exam question	Suppose a gas pipe feeding a small town is reaching the end of its asset life. Is it better to replace the pipe like-for-like, convert the town to electric heating or install a biomethane plant and upgrade the gas network?
Commentary	There is a need to ensure existing assets are well maintained. However, non-load related spend can form a significant element of consumer bills. As assets reach their end-of-life, there is opportunity to consider whether it is best to replace them like-for-like or consider a different option. In this example, factors to consider would include: • Whether consumers are willing to switch to electric heating? • Whether the local electricity network can manage increased demand? • Precedent from the 2025 ban of gas heating in new homes • The incentives on a gas network to consider a whole system CBA Potential benefits of bringing forward versus deferring investment
Inputs considered	• Asset costs • Cost of disruption • Carbon footprint of delivering solution • Ongoing maintenance costs • Current CBA process for asset replacement (this would provide options)
Benefits considered	• Lower bills • Reduced emissions • Minimisation of risks • Reliability of different solutions

Counterfactual	The counterfactual is the minimum investment needed to maintain compliance with licence obligations. In this case, it is likely to be a maintain and fix on failure by the asset owner, who is the current decision maker.
Stakeholders	• Network owners and operators • Generation / commercial solution providers • Local community
Order of magnitude of benefits	Tens to hundreds of millions, given past and expected levels of asset replacement spend
Practicality	Hard – this is a classic CBA use case, but needs regulatory change

Table 3 – Use Case 1: Asset replacement

Use Case 2	Investment planning
Exam question	Suppose an electricity line is heavily constrained. From a whole system perspective, what is the best solution?
Commentary	This can be considered as an extension of the current *NOA* process[18]. The *NOA process* will be expanded to consider commercial solutions. However, these will only value the commercial solutions on their ability to manage the constraint (and the implementation cost). rather than any other whole system consideration. A whole system CBA could be used to expand the assessment to consider whether the best solution is: • Installing a battery • Encourage demand-side response or load-shifting • Building a hydrogen plant and a new pipeline to transport clean heat to a nearby town • Network reinforcement or new build
Inputs considered	• Cost of asset and commercial solutions • Cost of disruption • Carbon footprint of delivering solution
Benefits considered	• Lower bills (optimal balance between network investment and constraint spend) • Reduced emissions • Wider societal and environmental benefits
Counterfactual	Viewed as an extension of the current NOA process, the counterfactual would be the output of the existing NOA process. Otherwise, a more generic counterfactual of managing the constraint in the balancing mechanism. Decision maker is the network company/commercial solution developer (who may be acting on the NOA recommendations).
Stakeholders	• Network owners and operators • Commercial solution providers • Local community (in the example of the third bullet point in the commentary)
Order of magnitude of benefits	Billions, given the current spend in investment planning considered over asset lifetimes.
Practicality	Hard – needs regulatory change

Table 4 – Use Case 2: Investment planning

Use Case 3	Embedded generation
Exam question	A farmer wants to build a biogas plant running on agricultural waste. Should it generate electricity or enter the heat network?[19]

[18] For the sake of the example we consider this from an electricity constraint perspective. There are equally applicable examples that could be used in the gas of a gas constraint
[19] Other examples could include a small wind farm deciding whether to install a battery or electrolysis plant

Commentary	As noted by the CCC[20], a regulatory and support framework for low-carbon heating (heat pumps, biomethane and networked low-carbon heat) is needed to enable the transition to low-carbon heating by 2050. As the UK electricity system decentralises, there is also expected growth in embedded generation, including from biofuels. Installed capacity of biogas could triple by 2030[21]. Factors to consider include: • Costs of gas and electricity assets • Needs of local area (eg the area has a lot of embedded wind generation so gas is needed but that would require a more expensive pipe) • Gas quality challenges from biogas (calorific value, odourisation)
Inputs considered	• Cost of assets • Cost of disruption • Carbon footprint of delivering solution
Benefits considered	• Reduced emissions • Lower bills (eg potential local constraint or operability savings)
Counterfactual	Do nothing. Decision maker is the developer of the proposed asset.
Stakeholders	• Embedded generators (eg farmers, waste water companies) • Local authorities – they may have local net-zero targets that this can help with • Local community
Order of magnitude of benefits	Given the small-scale nature, we estimate this to be in the millions. However, if the carbon price is high in future years, this could move into the tens of millions.
Practicality	Medium – will need appropriate incentives for generators

Table 5 – Use Case 3: Embedded generation

Use Case 4	Local authority planning
Exam question	A local authority has been given £50 million funding from central government to support decarbonisation in their area. How should they spend it?
Commentary	Local and regional authorities are increasing investing for net-zero. Bristol City Council has recently declared a "climate emergency" and has identified £875 million of investment opportunities over the next 10 years[22]. Cornwall is trialling a local energy market approach (Cornwall Energy Island) due heavy constraints in the area[23]. A whole system CBA could be help to help them target investment to maximise consumer and societal benefits
Inputs considered	• Investment costs • Cost of disruption • Carbon footprint of delivering solution • Current and future supply and demand scenarios
Benefits considered	• Reduced emissions • Lower bills (eg potential local constraint or operability savings) • Societal benefits (eg benefits to local businesses and communities through job creation, future economic growth)
Counterfactual	Do nothing. Decision maker is the local authority.
Stakeholders	• Local authorities • Local communities and business (eg transport providers, housing developers) • Local energy networks and providers

[20] Committee on Climate Change: Net-zero – the UK's contribution to stopping global warming (page 200) https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf
[21] FES data workbook – Electricity supply data table ES1. Capacity filtered by Anaerobic digestion, Anaerobic digestion CHP, Biogas CHP, Biofuel and Biofuel CHP.
[22] Bristol City Council and Energy Service Bristol: City Leap Prospectus https://www.energyservicebristol.co.uk/wp-content/pdf/City_Leap_Prospectus%204-5-18.pdf
[23] https://www.cornwallislesofscillygrowthprogramme.org.uk/projects/local-energy-market/

Order of magnitude of benefits	Benefits potentially in the tens of millions at first, to hundreds of millions later.
Practicality	Easy – there are existing tools and processes

Table 6 – Use Case 4: Local authority planning

Use Case 5	Strategic planning
Exam question	What is the best way for the UK to meet its net-zero target?
Commentary	The cost of meeting net-zero is enormous. The CCC estimates it is likely to cost over £50 billion per year[24]. Important decisions around who funds this need to be made. The CCC also states that the economic impact of hitting net-zero could also be positive. A whole system CBA could be used to maximise the chance of this. A whole system CBA could look at certain sectors (eg should EVs or hydrogen be used for transport, do we use gas or electricity for heating) or more overarching (what is the cost of the different FES scenarios)
Inputs considered	• Investment costs • Technology costs • Market conditions • Consumer behaviour • Government policy
Benefits considered	• Lower bills • Reduced emissions • Societal benefits (eg health, inequality, fuel poverty, vulnerability)
Counterfactual	Do nothing. Decision maker is UK government
Stakeholders	• Governments (all levels) • Regulators • Business • Consumer groups • Network and non-network energy companies • Committee on Climate Change
Order of magnitude of benefits	Billions to trillions
Practicality	Medium – there are numerous factors and trade-offs that need to be considered

Table 7 – Use Case 5: Strategic planning

Discounted use cases

Some ideas were discounted. These were mainly in areas where greater coordination, rather than a whole system CBA, is a better solution. These include:

- Roadway works, for example coordination of asset maintenance.
- Joint outage planning, for example optimising maintenance across a gas network, power station and electricity network

[24] Committee on Climate Change: Net-zero – the UK's contribution to stopping global warming (page 229) https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

Part 3 – Wider considerations

Stakeholders
A wide number of stakeholders will need to be involved in the development and use of a whole system CBA. Examples of key stakeholders are identified in the table below; this is not an exhaustive list. We have indicated what their potential role could be, but this may vary depending on the use case.

Interested party / user/ decision maker / impacted

Group	Stakeholders	Role(s)
Government	Central government, devolved administrations, regional governments, local authorities	• Investment decision maker • Investment decision approver (eg planning permission)
Regulator	Ofgem, and potentially wider regulators if considering other utilities	• Approver of whole system CBA methodology • Investment / funding request decision approver
Consumer groups	Citizens Advice	• Interested / impacted party – consult on methodology
Energy companies	Network owners and operators, generators, suppliers, aggregators, service providers, code administrators	• Investment decision maker • Interested / impacted parties – consult on methodology
Campaign groups	WWF, National Trust, Campaign to Protect Rural England	• Interested / impacted parties – consult on methodology
Academia and policy	Universities, academics, think thanks	• Interested party – consult on methodology
Expert groups	Committee on Climate Change	• Interested party – consult on methodology

Table 8 – Stakeholder groups

We recommend engaging with some of these key stakeholders during the phases 2 and 3 of the project. A key output of phase 2 should be the creation and execution of a detailed stakeholder engagement plan.

Challenges to implementing a whole system CBA
The group has identified several challenges that need reviewing and potentially overcoming to use and realise the benefits of a whole system CBA. It is recommended that these challenges are furthered assessed, including through stakeholder engagement, and solutions identified, in phase 2.

Regulatory frameworks
Regulatory frameworks will need to drive/incentivise the right behaviour to enable optimal whole system outcomes. For example, in the use case 1 above, there needs to be an incentive on the gas network owner to conduct a whole system CBA that may result in the optimal decision being a non-gas network solution. A potential solution is to allow the existing asset owner to capture some of the benefits of the chosen solution.

As part of their price control deliverables, network companies will have committed to a number of outputs, including reducing risk and delivering large capital projects. The regulatory framework needs to be flexible enough to accommodate the transfer of responsibility, if that is suggested by the whole system CBA. In addition, there may be a misalignment between who pays for a whole system solution versus who benefits from it, which may discourage investment. Decisions will need to made on whether the developer pays or if the cost is socialised. This will have implications for allowances – in principle there should not be winners and losers. A company should not be penalised because the responsibility has been transferred, because they have acted in consumer interest. There may need to be a way for settlements to be protected or for the company transferring responsibility to retain a share of the benefit.

The converse should also be considered – a whole system CBA could be used to assess the benefits of changing the regulatory framework.

Data sharing
A whole system CBA will need data inputted from across the energy sector. In some cases, this data may not currently be shared due to commercial or reasons. Appropriate frameworks need to be introduced to allow data to be shared and analysed from different organisations across the energy system. Network companies may need to become more comfortable sharing data. In other cases, it may be a lack of visibility or understanding of data that is a challenge. Network companies should work together to identify what data is needed and routes for sharing this. This includes implementing the recommendations of the Energy Data Task Force[25].

Forecasting costs and benefits
It is challenging to forecasts costs and benefits, especially over the long term. Especially in use cases 4 and 5, estimates of future market and technology costs would be needed. Whilst robust published estimates are likely to exist, the appropriate sensitivities analyses should complement these. Trialling the whole system CBA on smaller, targeted use cases (like use cases 1, 2 and 3 above) would help develop best practice in forecasting costs and benefits.

Understanding of opportunities
There are currently limited gas and electricity interactions, although there is a lot of work across industry at the moment to address this. This work, including better visibility of data, suitable regulatory frameworks and more information sharing could help parties understand the potential opportunities for whole system outcomes in areas where there are not currently any. The whole system CBA could then be used to decide on optimal investments. Regulators and industry bodies (eg the ENA) all have a key role to play in encouraging whole system interactions and data sharing.

Establishing a counterfactual
The counterfactual for network CBA is usually the minimum investment required to maintain compliance with licence obligations. A current challenge is that there may not be clear and/or shared understanding of what this is. A clear counterfactual is needed to accurately assess the costs and benefits of different options. For asset investments, a default counterfactual should be maintaining the asset and repairing it when it fails but this may not always be appropriate and the counterfactual should be a relatively credible option.

[25] Energy Data Taskforce: A Strategy for a Modern, Digitised Energy System
https://es.catapult.org.uk/news/energy-data-taskforce-report/

Part 4 – Conclusions and recommendations

Conclusions
As evidenced in the use cases, a whole system CBA has the potential to drive significant benefits for consumers and help the UK meet its net-zero obligations. The benefits of a whole system CBA are almost certain to outweigh the cost of developing it. Several areas need working up into more detail during phase 2, including:

- Detailed specification and parameters, building on the broad principles in this report. This can be done via a trial.
- Wider stakeholder engagement around the use cases and key parameters, and other out of industry examples of best practice.
- Further consideration of whole system interactions, and the challenges to interactions, to identify further use cases for a whole system CBA.

Recommendations for a whole system CBA

- A whole system CBA should be used where it meets the three tests. There will be circumstances where a sector specific CBA is more appropriate. Further engagement, especially with Ofgem, should be conducted on this. This could include an opportunities for using a whole system CBA in RIIO-ED2.
- A whole system CBA should be developed via a trial as in Use Case 4 above. We recommend partnering with WS4 P4 (Investment Planning), given the relationships that product has with local authorities.
- Feedback from this should be incorporated before it is more widely rolled out. We envisage there being one whole system CBA, which can be tweaked depending on the use case.
- Current CBA models and methodologies, like grounding in the HM Treasury Green Book, should be incorporated. The whole system CBA should reflect any updates to these.
- Network and non-network energy companies, Ofgem and BEIS should work together to identify and remove challenges that could prevent a whole system CBA being used for optimal decision making.
- The Open Networks Steering Group and Gas Futures Group should authorise phase 2 of Product 1. A high-level work plan is proposed below.

Proposed phase 2 work-plan

- Development of a full phase 2 workplan, for review and approval by WS4.
- Building up and trialling a use case (based on use case 4 in this report).
- Development of the whole system CBA methodology and model, building on the broad principles in this report. This is likely to include:
    - Further development of the tests for a whole system CBA
    - Identification and monetisation of costs and benefits
    - How to incorporate qualitative costs and benefits
    - Scenario and sensitivity analysis
    - The decision-making process
- Further work to identify and overcome the challenges to a whole system CBA listed in this report.
- Creation and execution of a detailed stakeholder engagement plan to guide this work.

In line with the P1 timescales for Phase 2 and 3 in the PID and the P4 timescales, it is envisaged that this work would be completed by the end of September 2020, and signed-off in October 2020, but this would be kept under regular review. Given the recommendation would see overlap between Phases 2 and 3 as described in the PID, a further extension to December 2020 would be aligned with the original PID timescales. Monthly updates would be provided to WS4.

Resourcing
It is possible that some external support (eg consultancy) will be needed alongside the current project group. A rough estimate is that this could cost around £20,000.

The current project group (listed at the front of this report) would continue working on the project in line with the original commitments (around two days per month). It should be noted that due to RIIO-2 draft determinations being due in July 2020 and the current covid-19 situation, project group availability may be limited.

Part 5 – Next steps

A summary of the next steps in given below.

Date	Stakeholder	Purpose
Mid-April	Steering Group and Gas Futures Group	Sign-off. Approval to start phase 2.

Table 9 – Summary of next steps