Energy Systems Catapult

Analysing the Costs and Benefits of Local Area Energy Planning

Findings and recommendations report

REP01

Issue | 20 May 2019

Job number 265935-00

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Document Verification

ARUP

Job title	Analysing the Costs and Benefits of Local Area Energy Planning	Job number 265935-00
Document title	Findings and recommendations report	File reference
Document ref	REP01	

Revision	Date	Filename			
Draft 1	4 Mar 2019	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Chris Pountney	Stephen Cook	Stephen Cook
		Signature	CP	SC	SC
Draft 2	15 Mar 2019	Filename			
		Description	Second draft, responding to ESC comments		
			Prepared by	Checked by	Approved by
		Name	Chris Pountney	Stephen Cook	Stephen Cook
		Signature	CP	SC	SC
Draft 3	01 Apr 2019	Filename	Report_ESC_LAEP_counterfactual_Draft-3_2019-03-20.docx		
		Description	Update following client comments		
			Prepared by	Checked by	Approved by
		Name	Chris Pountney	Stephen Cook	Stephen Cook
		Signature			
Final	16 May 2019	Filename	Report_ESC_LAEP_CBA_Issue_2019-05-14.docx		
		Description	Final draft		
			Prepared by	Checked by	Approved by
		Name	Chris Pountney	Stephen Cook	Stephen Cook
		Signature	CP	SC	SC
Issue	20 May 2019	Filename	Report_ESC_LAEP_CBA_Issue_2019-05-20.docx		
		Description	Finalised for issue following ESC feedback		
			Prepared by	Checked by	Approved by
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Issue Document Verification with Document ✓

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1 Introduction

1.1 Background

The Energy Systems Catapult and Energy Technologies Institute have developed a whole systems energy modelling capability called EnergyPath Networks (EPN). EPN generates optimised scenarios for local area energy transitions based on target outcomes of carbon savings to meet national targets at the least economic cost (or the greatest economic benefit).

A key finding of ESC's research is that local area energy strategies are a prerequisite to achieving energy transition, on the basis that a nationally-led approach will not take account of local characteristics which will be important in defining the best local outcomes. The ESC's case is that locally optimised approaches are only possible if a local area energy planning process is in place to direct and guide investment and behaviour of local government, developers, utilities, building owners and citizens.

ESC's hypothesis is that without local area energy planning (LAEP), it will be hard to achieve change at the scale required, the cost of the energy transition in a given local area will be higher and/or the benefits lower than if LAEP is in place.

1.2 Purpose

The purpose of this study is to identify evidence to test the ESC's hypothesis, and to develop a definition and cost-benefit assessment of delivering the optimised EPN scenario under 'planned' versus 'unplanned' scenario variants.

This report presents the results of the study.

1.3 Scope

The scope of the study was to:

- review the literature on the value of local area energy planning;
- define 'planned' and 'unplanned' scenario variants (i.e. with and without LAEP) and describe the relevant cost and value parameters for these;
- produce a high-level cost-benefit assessment (CBA) spreadsheet following standard discounted cash flow model structure; and
- set a research agenda for refinement of the CBA.

1.4 Approach

Our approach comprised four main strands:

- Review of data and outputs from EPN, provided by ESC. This included review of the results of ESC's work for Bury (in the Greater Manchester area) and its previous publications on local area energy planning.
- Literature search: searches among relevant journals and grey literature for evidence of the value of local area energy planning, and of spatial planning more generally.
- Workshop-led development of scenario variants: Regular engagement and two workshops with ESC helped to steer our thinking.
- Consolidation into a short report and simple CBA model (spreadsheet).

1.5 Limitations

The following limitations are noted:

- This commission was for a targeted, scoping-type study. The outputs include a structure for the scenario variants and CBA, but gaps and assumptions will need to be filled in and verified through further investigation and analysis.
- We sought to define 'planned' and 'unplanned' scenario variants which were both consistent with the overall optimal outcome produced by EPN. In other words, our scenario variants assume that the 2050 energy system is the same as that defined by EPN, but the cost of achieving that system outcome is affected by the factors which can be influenced by the presence or absence of a local area energy strategy.
- Related to the previous point, the CBA model was designed to draw upon the outputs of the EPN model. It is also designed to enable both scenario variants to be tested without the need to re-run the EPN model.

2 The value of planning

It may be taken as a generally accepted truth that good planning leads to more efficient outcomes and greater economic benefits for the system which is being planned. However, quantifying the actual economic effect of planning is far less certain.

For instance, the UK's development planning and control system was established in 1947 and so has the benefit of over seventy years of established practice and related research. Despite this pedigree, a recent Royal Town Planning Institute paper concludes that 'we still have only limited knowledge of the economic impact of planning.'[1] This paper found that recent attempts to quantify the value of planning found that the economic impact was adverse but that these studies fail to recognise the entire role of planning and instead focus on its narrow regulatory role. It concludes, 'Consequently, such studies not only fail to assess the 'costs' of planning reliably; they also neglect its benefits.'[2]

Within the limitations of this study we have not found a ready body of evidence to demonstrate the value of planning in general or of energy planning in particular. Nevertheless, we have identified a range of examples which provide some evidence that energy planning can have a positive impact on outcomes and that unplanned or rushed decision making can have adverse and unintended consequences.

2.1 Examples of the impact of energy planning

Energy Efficient Scotland

The Scottish Government's climate change plan includes the following commitments for 2032 in relation to electricity and buildings:

- 35% of heat for domestic buildings will be supplied using low carbon technologies, where technically feasible
- 70% of heat and cooling for non-domestic buildings will be supplied using low carbon heat technologies
- Improvements to the building fabric of Scotland's buildings will result in a 15% reduction in residential and 20% in non-residential heat demand

The Scottish Government has established the 20-year Energy Efficient Scotland[3] (EES) programme to drive the delivery of these commitments. Recognising the scale and technical complexity of the programme, the range and sheer number of stakeholders involved and its far-reaching and ambitious targets, the government is considering how to establish a national delivery mechanism (NDM) to drive delivery of objectives and targets across multiple parliamentary cycles and

[1] Adams and Watkins 2014. The Value of Planning: RTPI Research Report No. 5. Page 71. Available online at https://www.rtpi.org.uk/media/1024627/rtpi_research_report_value_of_planning_full_report_june_2014.pdf
[2] Adams and Watkins 2014. Op. cit. Page 3.
[3] Formerly called Scotland's Energy Efficiency Programme (SEEP)

maximise societal-wide benefits, including fuel poverty, health, regeneration, economic and environmental benefits.[4]

The government is currently debating the form the NDM will take, but it does recognise that some form of active approach to planning and delivery of the programme is essential to the success of the programme.

A central feature of EES is the proposed responsibility to be placed upon Scottish local authorities to prepare Local Heat and Energy Efficiency Strategies (LHEES). The LHEES would 'set a framework and delivery programme for how each local authority would both reduce the energy demand and decarbonise the heat supply of buildings in its area, to ensure progress against the national objectives.'[5]

It is early days for the EES programme and for LHEESs, so we cannot draw conclusions on what impact these energy planning efforts at regional and local level will have. However, it is clear that the Scottish Government has acted upon a reasoned conclusion that energy planning – including local energy planning - is an essential requirement to deliver on the commitments for a radical energy transition in Scotland.

Decentralised energy planning in London

Decentralised energy (DE) development has been a key feature of policy in London, with a mayoral commitment from the late 2000s to supply 25% of London's energy needs through decentralised sources, by 2025. Planning policy in London has actively supported and enforced development of district heating networks since 2008, and successive programmes has deployed technical assistance to bring new DE projects to market.

The effect of a consistent policy environment can be observed in the development of major district heating networks across the capital, including Olympic Park, Kings Cross, Vauxhall Nine Elms, Southwark, Enfield, Islington and Camden are all examples of the impact of these policies.

Programme support has also been effective: the £3m Decentralised Energy for London programme was 90% funded by the EC and brought over £100m worth of projects to market. It has actively supported 18 DE projects worth c.£150m and has exceeded its target 25:1 leverage ratio of capital investment brought to market. This illustrates that this is a highly effective approach that has been able to coordinate activity across London and engage extensively with both public and private sector stakeholders.[6]

[4] KPMG and Arup 2018, 'Energy Efficient Scotland: Strategic Outline Case for Proposed Development of a National Delivery Mechanism, draft report 7 December 2018.' Unpublished manuscript.
[5] Scottish Government 2018, 'Scotland's Energy Efficiency Programme: Second Consultation on Local Heat & Energy Efficiency Strategies, and Regulation of District and Communal Heating'
[6] GLA 2016. 'Energy for London Request for Mayoral Decision.' Available online at: https://www.london.gov.uk/sites/default/files/md1542_energy_for_london_signed_pdf.pdf

2.2 Impact of rapid or rushed change

Australian energy market

Australia's energy market has experienced a rapid rise in costs, with evidence of significant overinvestment relative to demand. The roots of this situation lie in a rapid growth in demand in the 1990s from mining activity and household purchases of air conditioners. A series of load-shedding events in 2004 led to more stringent grid reliability policies which required increased investment in the country's grids.

Although load was forecast to continue a rapid rise, in fact the experience was that demand growth was slower. In addition, investment in solar PV was also rising rapidly, which further reduced total demand.

As a consequence of these investment drivers, the Regulatory Asset Base (RAB) of electricity networks across Australia's National Electricity Market tripled in value from 2004 to 2018, from $32 billion to $93 billion.[7]

Energy costs have risen rapidly for customers, which has driven further investment in solar, with a further 'hollowing out' of demand, driving yet further rises in unit costs.[8]

For the purposes of this paper, the Australian experience highlights the complexity of interaction between policy, demand and markets, and the risks of unintended consequences of rapid and reactive policy changes.

The Australian example also offers potential lessons in how to manage an oversized utility asset base. This is potentially the situation to be confronted in the UK with falling gas demand to meet carbon reduction policies. Both national and local planning will be needed to manage the reduction of the gas asset base as demand for gas falls.

The *Energiewende* in Germany

Germany has been a leading example of a country committed to the development of renewable energy, but it is also experiencing adverse impacts of the nature of the decisions taken and the pace of change which has occurred.

Germany's commitments on energy and climate change are:

- Reduce GHG emissions by 40% by 2020 and up to 95% in 2050 from a 1990 baseline
- Increase the share of renewables in (gross final) energy consumption to 60% by 2050

[7] Simshauser and Akimov, 2018. 'Regulated electricity networks, investment mistakes in retrospect and stranded assets under uncertainty.' University of Cambridge Energy Policy Working Group. Available online at https://ideas.repec.org/p/cam/camdae/1853.html
[8] Ibid.

- Increase the share of renewables in (gross) power consumption to a minimum of 80% by 2050.[9]

After the 2011 Fukushima accident in Japan, Germany announced that it would phase out nuclear generation from its energy mix. Germany also provided sustained and generous support for solar, in spite of its small contribution to the overall energy mix, especially during peak demand periods in the winter. Onshore wind, which provides more cost-effective generation, has received lower subsidy.[10]

The effect has been dramatic, with installed capacity of renewable energy systems rising from 11GW in 2000 to 104GW in 2016, about the same capacity as conventional generation sources at that time.[11]

Germany and its neighbours have experienced adverse impacts from the rapidity of the change along with the particular decisions which have driven the change. These include:

- High reliance on neighbouring countries to maintain grid stability in the face of intermittent renewables, because of delayed investment in electricity transmission and storage infrastructure
- Higher costs of electricity network infrastructure due to undergrounding of urgently needed power lines to overcome public objections
- GHG emissions have fallen less quickly than they could have, due to the decision to phase out nuclear and the need to retain conventional coal-heavy generation to balance intermittent renewables
- The highest household cost of electricity in the EU (EUR0.28/kWh), with decreasing willingness to pay among the German public[12]

As one recent paper notes: 'Renewable energy expansion is proceeding ahead of schedule and grid reliability remains high, but this comes at a cost that is more than double original targets.'[13]

For this paper, the German experience highlights how a rapid and complex programme of change can be exposed to high risk of delay or higher costs. Germany did not wholly lack planning, but the reactive decision to phase out nuclear appears to have exacerbated an already challenging situation while undermining the objective of carbon reduction. A further impact has been failure

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[9] Hedberg 2017. 'Discussion Paper: Germany's energy transition: making it deliver.' European Policy Centre, October 2017. Available online at: http://aei.pitt.edu/91830/1/pub_7997_germanyenergytransition.pdf
[10] Ibid.
[11] Andor, Frondel and Vance 2017. 'Germany's Energiewende: A tale of increasing costs and decreasing willingness to pay.' IAEE Energy Forum. Available online at: https://www.iaee.org/en/publications/newsletterdl.aspx?id=439
[12] Andor, Frondel and Vance 2017. Op. cit.
[13] Cloete 2018. 'Energiewende enters a new phase – how is it performing?.' Energypost.eu, 7 August 2018. Available online at: https://energypost.eu/energiewende-enters-a-new-phase-how-is-it-performing/

to expand new grid infrastructure rapidly enough to match the changing geography of generation.

2.3 Defining a Local Area Energy Strategy

A key finding of ESC's research is that LAEP is necessary to achieve the least cost energy transition pathway, on the basis that national, 'one size fits all' approaches do not achieve the optimal outcome. The ESC's case is that locally conceived approaches are only possible if a local area energy planning process is in place.

In this study we are seeking to create a structure to compare the cost of LAEP with its benefits. In order to quantify the cost of LAEP it is necessary to establish the scope of LAEP. The ESC has produced an extensive literature on LAEP, within which some defining features are offered:

> *To be effective, the [local area energy] planning process should be centred around a collaborative and open dialogue between local government, network operators and other stakeholders... Insights from local areas can be considered alongside top-down Whole Systems modelling to help assess energy system choices, before planning for the delivery of energy networks upgrades and changes to homes and buildings that are needed to deliver a low carbon and clean energy future...*[14]

> *Local government can take a lead role, as it is best placed to guide the transition so that it considers and benefits an area's residents and businesses, whilst considering local priorities. Local government is one of the very few organizations committed to a local area for the long term and their status makes them an effective route to engaging many different stakeholders in decision-making in all aspects of the local energy system.*[15]

The ESC's work to date sets out a clear framework for preparing the evidence for the local area energy strategy and identifies key stakeholders to be involved in the process. It also identifies roles during implementation of the adopted strategy.

Based on our review, two interrelated questions remain unanswered:

- What weight will the adopted strategy have?
- What are the rules for preparation and adoption of a local area energy strategy?

These are considered in turn.

2.3.1 Weight of the strategy

Development planning in the UK is a statutory process which has evolved since the first Town and Country Planning Act was enacted in 1947. The powers and

[14] ESC 2018a. Local Area Energy Planning: Supporting clean growth and low carbon transition. Energy Systems Catapult, October 2018, page 15.
[15] ESC 2018b. Local Area Energy Planning: Guidance for local authorities and energy providers. Energy Systems Catapult, October 2018, page 15

responsibilities of designated local planning authorities are set out in statute, as are the procedures for plan preparation and adoption. The UK's plan-led system means that approval of planning applications must normally be granted only if the proposed use or development conforms to the development plan.

The weight of the adopted development plan is therefore very significant. Local planning authority decisions are taken on the basis of the plan, and these decisions affect developers, statutory undertakers, NGOs and communities. These parties participate in the plan making process, including contesting and/or advocating particular outcomes.

By contrast, some local authorities have also chosen to prepare climate action plans or similar strategies to identify pathways and actions for carbon reduction and climate adaptation. These are voluntary plans and they carry no statutory weight. Consequently, such plans act only as a political commitment to action by the local authority itself. Their lack of statutory weight means they cannot be used to oblige or prevent actions by parties outside the local authority.

In Scotland, the Scottish Government has proposed that every local authority will have a duty to prepare a local heat and energy efficiency strategy (LHEES).[16] The exact form and weight of the LHEES is not fully confirmed, but these documents appear to fall somewhere in between a statutory development plan and a voluntary climate action plan.

Reflecting on this brief discussion, we note that the status of a plan matters. A voluntary strategy can be a politically effective way of building consensus and securing commitments across different actors, but it will not be able to force the kind of investment required to transform our energy system, nor to mediate between the competing interests of gas, electricity and district heating operators. The changes required to decarbonise our energy system are radical and urgent; they will not be delivered with a voluntary strategy.

2.3.2 Rules of strategy preparation and adoption

A local area energy strategy (LAES) which forcefully shaped the investment plans of network operators, property owners and generators would need to have some of the procedural features of development plans. These would include opportunities for consultation with the public and stakeholders, and some form of oversight. A system of national guidance would also be needed to ensure a consistent quality standard and compatibility between strategies. Such a process might include the stages of:

- Evidence base
- Issues and options
- Draft strategy
- Examination in public
- Final strategy
- Review and challenge window

[16] Scottish Government 2018. Op. cit.

Each of these stages could have a component of public and stakeholder engagement and consultation.

The ESC has identified that local authorities should prepare local area energy strategies. This tier of government is the default 'local' tier, and is the approach being proposed by the Scottish Government for the preparation of LHEES. This would suggest that 391 strategies will be needed to cover the UK.

Other options for bodies to prepare the strategies include devolved administrations (DAs), combined authorities (including the GLA), counties and local economic partnerships. Taking a hybrid approach of DAs, combined authorities and counties could bring the number of strategies needed to around one hundred.

Deciding on the appropriate entity for strategy preparation will be a balanced judgement between:

- local accountability and understanding;
- practical energy system modelling limitations; and
- economies of scale and having a critical mass of the required skills and capacity.

In Scotland, local authority consultation responses highlighted a concern with the cost of preparing an LHEES, and of having the right resources.[17] In the case of LAES, both of these risks could potentially be mitigated by reducing the number of separate bodies tasked with preparing and implementing strategies.

[17] Why Research 2017. Analysis of responses to the Consultation on Heat & Energy Efficiency Strategies, and Regulation of District Heating. Scottish Government.

3 Comparing costs and benefits

3.1 The strict counterfactual definition

In HM Treasury Green Book terms, the 'counterfactual' is a 'do nothing' scenario which defines the base case condition when demonstrating the costs and benefits of a policy intervention. In the context of this work, the counterfactual would describe the energy transition in an area of interest, had the LAES not been produced and acted upon. In this case, the counterfactual would include existing policies, while markets would be assumed to continue to behave in a similar manner, i.e. respond to price signals to deploy new technologies.

Thus, the counterfactual does not guarantee to deliver the same outcome as the proposed intervention. It is simply designed to provide a comparative future which is based most closely on the current situation.

3.2 The cost-benefit comparison

The aim of this study was to illustrate the benefit of having a plan compared with not having a plan. Reducing this to its simplest form, the intention was to design an alternative future which is fixed, as far as possible, to the optimal EPN scenario (i.e. the proposed solution)..

This is not a strict counterfactual case. Rather, in both scenario variants (planned andunplanned), the optimised energy and carbon emissions outcome is achieved at the end of the modelling period, using the same set of technology solutions selected by the EPN model. The difference is the route to implementation:

- In the planned future, implementation is smooth and timely.
- In the unplanned future, implementation is patchy and non-linear, with delayed progress in the early years followed by a rush to meet the target.

This approach has the advantage that it does not require a detailed projection of future UK Government policy or assumptions on the uptake of different individual technologies. It should not necessitate re-running the EPN model. Of course, it is possible to describe an unplanned alternative in the near term based on these drivers (e.g. ECO-3 delivers 1.24 million energy efficiency measures between 2018-2022), but there is no way to continue that approach to even the mid-term.

Furthermore, the comparison proposed here does not address the number of other alternative futures that might be considered during the LAEP process. For example, it may well be of interest to compare the set of technology solutions selected by the EPN model with a hydrogen-based future, or a full-electric future. These comparisons can be analysed but do require a re-run of the EPN model under different constraints and assumptions.

3.3 Defining the cost-benefit

Initial discussions identified a wide-range of benefits that may arise from LAEP. These included, making the best use of capital investments, attracting inward investment, creating jobs, reducing energy bills, reducing fuel poverty, improving air quality and health outcomes. These can be captured broadly under two categories, either monetised, or non-monetised benefits.

The selected costs parameters were selected based on the following considerations:

- There was evidence or clear logic for a relationship specifically to the presence or absence of local area energy planning
- The parameters had a negligible overlap, so that double counting of costs and benefits could be avoided
- The costs or benefits were definable and could be quantified

The costs and benefits have been calculated in line with HM Treasury Green Book guidance including specific assumptions such as carbon pricing and discount rates. The CBA process takes the EPN outputs and discounts future costs to provide an overall view of the costs and benefits.

For each cost parameter, three values were selected, representing a central, low and high value. Central values were based on available evidence or agreed assumptions. High and low values were selected to provide scope for sensitivity analysis. Similarly, these were based on evidence where available, or agreed assumptions where not.

3.4 Types of costs used in the CBA model

The following types of costs were incorporated into the CBA model:

- Cost of LAEP
- Capex
- Fixed costs
- Resource costs (commodities)
- Variable operation and maintenance (VOM)
- Value of carbon
- Social cost (value of time)

The definition and scope of these types are the same as those used in the EPN model, with the exception of the cost of LAEP. This is not a cost within the model; its scope is defined in this report.

The following cost parameters were not included in the CBA model:

- Air quality and associated health impacts
- Fuel poverty and associated health impacts

- Job creation
- Inward investment

The limited nature of this study necessitated a focus on the direct cost differences between the planned and unplanned variants. In addition, these indirect costs could not be defined with any confidence without more extensive investigation.

The CBA model structure is flexible and can be readily edited to incorporate these other metrics in the future.

3.4.1 Process overview

To undertake the comparison, the EPN outputs are modified to produce two new cases ('variants'). **The 'planned' variant** is based largely on the EPN outputs, but since the EPN model cannot capture every benefit, the costs are refined and reduced. **The 'unplanned' variant** uses the same EPN outputs but defers the deployment of energy interventions and/or increases the associated costs.

The process for creating this comparison is designed to be independent of location, using only the outputs of the EPN model, along with a series of adjustment assumptions.

The outputs from the EPN model required for the CBA analysis include:

- Detailed breakdown of nominal costs, for buildings, networks, resources and technologies, split between capital, fixed and variable operations and maintenance (VOM) cost categories.
- Annual demand, for buildings, appliances, energy centres, electric vehicles and lighting, split by resource type.
- Annual emissions, for buildings, grid electricity and energy centres.
- Estimates of network length, number of LV substations and the number of buildings, split by each area of interest.

4 Cost parameters

This section describes the main drivers of different economic impacts between the two variants.

4.1 Cost of Local Area Energy Planning

Description

As noted previously, local area energy planning involves a process of developing the evidence base by use of a whole systems energy modelling approach (e.g. using EPN). A participatory process involving the local authority and other key stakeholders would be conducted, with the output being an adopted local area energy strategy.

Evidence

Cost estimates of LAEP by ESC range from £100,000 to £570,000 per authority. The higher figure represents the actual estimated cost during the pilot programme, while the lower figure is the estimated minimum figure, reflecting the opportunity for scale efficiencies when all local authorities are preparing LAESs.[18] Similarly, the Scottish Government consultation on LHEES mentions a local authority claim of £500,000 to prepare an LHEES.[19]

Through discussion under this commission, a central estimate of £300,000 has been agreed. We have assumed that the strategy is renewed every ten years, with the same cost each time.

The selected cost of LAEP reflects the costs to a local authority to commission or prepare the evidence (data collection, modelling, analysis etc), to engage with stakeholders, and to conduct the process of drafting and adoption of the strategy.

Table 1 Cost of local area energy planning

Variant	Output	Category	Nominal Cost			
			2015-24	2025-34	2035-44	2045-54
Planned	Operational Cost	LAEP	£300,000	£300,000	£300,000	£300,000

Low and high values for the LAEP cost parameter were:

- Low: £100,000 (lower end of ESC estimate)
- High: £600,000 (higher end of ESC estimate)

[18] ESC 2018a. Op. cit. page 43.
[19] Why Research 2017. Op. cit. page 75.

Exclusions

The LAEP cost parameter does not include the following:

- Participation of other actors in the plan preparation process, including network operators and generators, other interested energy companies, major landowners, other public bodies, NGOs, and members of the community. These costs would vary widely and would depend on the nature of the process which was established for the LAES. For a non-statutory process, it is assumed that such actors would provide their time free-of-charge, although in future there may be a case for funding certain community groups.
- Costs of a full statutory process of consultation and adoption, including examination in public. Our working assumption for this analysis is that such a process will not be adopted (discussed in section 2).
- Implementation of the strategy over the ten- to fifteen-year implementation period. It is not possible to estimate the part of these costs attributable to the strategy implementation.

4.2 Cost of acceleration

Description

The unplanned variant assumes that the optimal end-state is achieved, but only just in time. This means that the energy transition is delayed, but that somehow markets respond and deliver. Assuming no loss in quality (i.e. the same end-state), the implication is that supply chain constraints will increase delivery costs (following the laws of supply and demand).

The other consequence of delaying the energy transition is that carbon emissions reduce more slowly, so that the cumulative emissions are increased.

Additional benefits

Under the planned variant, supply chains can invest in capacity to meet expected demand.

A planned energy transition will lead to more consistent delivery and the opportunity to improve efficiency and to innovate over the period. Delaying investment also has wider implications for reduced national spending.

Evidence

According to the Office for National Statistics, wage and salaries annual growth rate for 2015 was 3.9%. The last decade has seen wage growth at similar levels. However, looking back over the past 30 years, annual growth has been as high as

11.9%.[20] An acceleration variant might lead to cost increases in the order of this historic high.

Another consideration could be the provision of overtime payments to accelerate delivery of works. Traditional overtime contracts typically pay 150% of normal wages for overtime.[21]

Limited evidence of the cost of acceleration was found in the course of this study. Extensive literature is available on the tendency of capital projects to overrun, which has led to the principle of "optimism bias" being incorporated into Green Book guidance. The guidance recommends an upper bound cost estimate uplift of 44% for standard capital projects and 66% for non-standard capital projects. The equivalent values for project duration are 20% and 25%.[22]

Other references identified include:

- An investigation in 2007 by the Taxpayers' Alliance found that 305 projects experienced an average cost overrun of 33.7%[23]
- A BBC article noting that the 2012 Olympics started with a cost estimate of £1.8bn and rose to £9.4bn by 2007 (a 522% cost increase).[24]
- A National Audit Office report on the Millennium Dome noted that the forecast costs would be 5% over budget, although the net grant increased by 57% (the Dome's notorious financial issues related mainly to the lack of private sector investors and disappointing visitor numbers).[25]

Drawing upon this varied evidence, we have selected the following structure to represent the potential cost of acceleration. The cost parameters are shown in the table below. These reflect the assumption that without planning the level of action is lower to begin with, then ramps up considerably towards the end of the period. Consequently, CO_2 emissions savings are slower and the total CO_2 emissions are greater. The particular approach pushes the near-term costs back into the mid-term, but the main additional cost is incurred in the final decade.

[20] Office for National Statistics, 2017. Wages and salaries annual growth rate %. Website and data download. Available online at https://www.ons.gov.uk/economy/grossdomesticproductgdp/timeseries/kgq2/qna
[21] Hart and Ma, 2008. Wage-Hours Contracts, Overtime Working and Premium Pay. IZA DP No. 3797. Available online at http://ftp.iza.org/dp3797.pdf
[22] HM Treasury 2013. Supplementary Green Book Guidance: Optimism Bias. Available online at https://www.gov.uk/government/publications/green-book-supplementary-guidance-optimism-bias
[23] Taxpayers Alliance 2007. Beyond the Dome: Government projects £23 billion over budget. Available online at https://www.taxpayersalliance.com/beyond_the_dome_government_projects_23_billion_over_budget#
[24] Wheeler 2007. "Why do costs over-run?" BBC News 16 March 2007. Available online at http://news.bbc.co.uk/1/hi/uk_politics/6210708.stm
[25] NAO 2000. The Millennium Dome. Available online at https://www.nao.org.uk/wp-content/uploads/2000/11/9900936.pdf

Table 2 Cost of acceleration cost parameters

Variant	Output	Category	Impact			
			2015-24	2025-34	2035-44	2045-54
Unplanned	Capital Cost	All categories	50% lower costs than Optimal	Unchanged costs from Optimal	50% of 2025-2034 costs + 2035-44 costs	150% higher costs than Optimal
Unplanned	CO_2 emissions	All categories	As per 2015-24 (same as planned variant)	As per 2025-34 (same as planned variant)	As per 2025-34	As per 2035-44

Low and high values for the cost parameters were selected for each decade:

Table 3 Low and High value cost parameters

Category	Impact			
	2015-24	2025-34	2035-44	2045-54
Low	25% lower costs than Optimal	Unchanged costs from Optimal	25% of 2025-2034 costs + 2035-44 costs	125% higher costs than optimal
High	75% lower costs than Optimal	Unchanged costs from Optimal	75% of 2025-2034 costs + 2035-44 costs	200% higher costs than optimal

4.3 Unnecessary expenditure

Description

There are various short-term investments that could be optimised with the certainty of a LAES. Cast iron gas network replacement, or electricity grid reinforcement, or even building energy efficiency retrofits might be dealt with differently if the system end-state was predetermined. For example, a gas boiler replacement could be delayed (unless the unit fails), on the understanding that a district heating network would be installed in the near-term. This could be even more pronounced at the network scale, where electricity networks may require two-stage reinforcement if EVs and electric heating become commonplace. The cost per unit of reinforcement falls for larger works, so a two-stage process is bound to be more expensive.

Additional benefits

Investment in the correct infrastructure will develop stronger, more certain industries which have the basis for growing the number of jobs.

Barriers

- Extending lifecycles of equipment beyond warranty periods or manufacturer's recommendations may meet with resistance from consumers.
- New market models may be needed to transfer switch responsibility from customer to ESCo.

Evidence

As described earlier in this report, Australian electrical networks experienced record levels of capital expenditure between 2005-2015. Unfortunately, this met with reduced demand from both industry and residential customers. The result was increased tariffs and stranded assets.

The study suggested that under a planned future, stranded assets could be more effectively managed and electricity tariffs could reduce by more than 20% over a 20-year period. This is an extreme example; however, an unplanned energy transition is bound to be far more vulnerable to this kind of mismatched investment.

The savings due to avoiding unnecessary expenditure are clearly hard to quantify. It should be noted that over-investment in energy efficiency is possible, current uptake would indicate that this is unlikely to be a serious concern. It is far more likely that unnecessary expenditure occurs in infrastructure networks; hence, the savings due to planning have been applied to the capital cost for new heat and electricity network infrastructure.

In lieu of further evidence, a small, notional reduction of 2.5% saving has been applied, on the basis that if it was likely to be larger that more evidence would be available.

Table 4 Unnecessary expenditure cost parameters

Variant	Output	Category	Impact			
			2015-24	2025-34	2035-44	2045-54
Planned	Capital Cost	Heat and Electricity Networks	-2.5%	-2.5%	-2.5%	-2.5%

Low and high values for the cost parameters were:

- Low: -1% costs
- High: -5% costs

4.4 Asset utilisation during transition

Description

The energy transition will mean the switching of many energy loads from one energy service to another, the most frequent being gas to electricity and gas to district heating.

An unplanned approach would lead to uncoordinated switching, with the result that DH network branches at their start, and gas network branches towards their end, could have very low utilisation, which would increase the cost of maintaining the infrastructure.

The converse would be more coordinated switching, e.g. so that entire branches switch at once, which maintains high utilisation for all utilities.

Barriers

Barriers to implementation of this opportunity include:

- Market model which creates competition between utility classes
- Customers may not be willing to switch; new market models may be needed to transfer switch responsibility from customer to ESCo.

The local authority could use the LAEP process to convene participants into a shared planning process and then to use the evidence of experience of barriers to engage with Government and Ofgem to provide funding or rule changes to unlock these barriers.

Evidence

Specific evidence was not identified that indicates the minimum viable utilisation level for utility networks, nor the likely cost penalty for maintaining networks with low utilisation.

In the absence of detailed evidence, the unplanned variant is assumed to incur 2.5% additional fixed costs on the basis that if it was likely to be larger that more evidence would be available. Detailed engagement with utilities could yield stronger evidence of this metric.

These additional costs are assumed to be borne by heat networks in the early years (as they grow) and by gas networks in the later years (as they shrink).

Table 5 Asset utilisation during transition cost parameters

Variant	Output	Category	Impact			
			2015-24	2025-34	2035-44	2045-54
Unplanned	Fixed Cost	Heat networks	2.5%	2.5%	0	0
Unplanned	Fixed Cost	Gas networks	0	0	2.5%	2.5%

Low and high values for the cost parameters were:

- Low: 1%
- High: 5%

4.5 Delivery efficiencies

Description

One recent infrastructure review states, 'To unlock investment in supply chain facilities greater visibility of demand and commitments to forward volume is necessary. The current market is typified by lack of visibility on both the demand and supply sides'[26]. An LAES could provide this at a local scale and this would allow supply chains to develop efficiencies and reduce delivery costs.

Additional benefits

Schools and universities can align their training and education agendas to the needs of the transition, as signalled by the supply chain investments.

Evidence

There is clear evidence that planned infrastructure investment can bring about efficiency savings. The 'Infrastructure Cost Review'[27] reported that implementing the findings of the 2010 review, capital costs had been reduced by 15% in the construction of new projects and programmes.

Since the local energy transition is far smaller than a national infrastructure project, the assumed efficiency savings are capped at 10%.

Table 6 Delivery efficiencies cost parameters

Variant	Output	Category	Impact			
			2015-24	2025-34	2035-44	2045-54
Planned	Capital Cost	All categories	-10%	-10%	-10%	-10%

Low and high values for the cost parameters were:

- Low: -5% costs (half the central value)
- High: -20% costs (twice the central value)

4.6 Maintenance burden

Description

A transition away from gas is likely to lead to stranded assets (i.e. assets unlikely to be supported by future net revenues), including underutilised gas networks that

[26] Construction Leadership Council 2017. Innovation in Buildings Workstream: Demand Creation, Investment and Volume Surety. Available online at http://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2017/11/Demand-Surity-Report-September-2017-VF-WEB-final.pdf
[27] HMT 2014. Infrastructure Cost Review: Measuring and Improving Delivery. Available online at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/330380/PU1684_-_Infrastructure_cost_review.pdf

have yet to reach end-of-life. In the extreme case, for example, an unplanned transition could result in a single gas user at the far end of a local section of distribution network.

The implication is that a planned withdrawal of the gas network would benefit from reduced maintenance costs. Decommissioning costs will be the same in both cases, although they may be delayed under the unplanned variant.

Additional costs

If maintenance does become a costly burden (in relation to fewer customers), there is the possibility that the incentive to save costs introduces higher safety risks. This should not occur, but commercial pressures will inevitably make it harder to undertake thorough maintenance.

Barriers

As noted in 'Asset utilisation during transition', there are significant regulatory factors which affect the deliverability of potential benefits of planning. In this case, a strictly ordered gas network withdrawal will require regulatory powers to switch end-users under the planned variant.

The LAES could provide the evidence to enable the local authority to engage with Government and Ofgem to provide funding or rule changes to unlock these barriers.

Evidence

According to a 2016 report for the Committee on Climate Change, average maintenance costs per km for UK gas networks is around £2,500/km/year.[28] There is significant uncertainty around the costs of decommissioning the gas network; nonetheless, the same analysis estimated average decommissioning unit cost of £30,000/km distribution network and £20,000/km of transmission network. This contrasts with the ETI's Infrastructure Cost Calculator that gives a range of £800-£7,000/km[29].

In the absence of additional data, under the unplanned variant, delays to decommissioning will be assumed to delay the reduction in maintenance cost by 10 years in the final two decades.

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[28] Aqua Consultants & Frontier Economics 2016. Future Regulation of the UK Gas Grid: Impacts and institutional implications of UK gas grid future scenarios – a report for the CCC. Available online at https://www.theccc.org.uk/publication/future-regulation-of-the-gas-grid/
[29] These costs are for capping and abandoning pipes, so some additional cost would be incurred for decommissioning valves, pressure regulators, etc. Costs extracted from the Infrastructure Cost Calculator by ESC.

Table 7 Maintenance burden cost parameters

Variant	Output	Category	Impact			
			2015-24	2025-34	2035-44	2045-54
Unplanned	Fixed Cost	Gas Networks	0	0	As per 2025-34	As per 2035-44

Low and high values for the cost parameters were:

Category	Impact			
	2015-24	2025-34	2035-44	2045-54
Low	0	0	0	As per 2035-44
High	0	As per 2015-24	As per 2025-34	As per 2035-44

4.7 Shared construction works

Description

Often, different utilities providers will need to access the same stretch of road to maintain independent networks. Through careful planning, utilities and developers will be able to coordinate on works planning. By aligning replacement cycles and agreeing to share sub-surface trenches, total civil engineering costs should reduce.

Additional benefits

The number of road closures should be reduced, avoiding reductions in workforce productivity and improving citizen satisfaction. Fewer traffic jams will also improve local air quality and reduce carbon emissions.

Barriers

Barriers to implementation of this opportunity include:

- Aligning replacement and maintenance programmes.
- Ensuring no negative impact on network lifespan.
- Developing contractual arrangements that acknowledge shared responsibility and risk.

The local authority could use the LAEP process to convene participants into a shared planning process and then to use the evidence of experience of barriers to engage with utilities and construction companies to provide funding or rule changes to unlock these barriers.

Evidence

A recent study concluded that sharing civil engineering costs could save £200/m length. Under typical conditions, this translates to a 1% reduction in pipe network capital costs.[30] This value has been selected for a capital cost saving estimate for the planned variant.

Social benefits of shared construction works come from reduced delay to the public and businesses. In 2017/18, the Department for Transport consulted on a new 'Lane Rental Scheme' which would introduce daily charges for utilities closing roadways for sub-surface construction. The consultation reported that the total cost of delay is around £4 billion per year, or around £1,600 per road work event. The current regulations provide for a daily charge for road works of up to £2,500 per lane per day, which provides a proxy for the social cost of road works.[31] This value has been selected for the social cost of delay. We have assumed that a saving of 6 months' worth of road works would be achieved per ten-year period (or around 18 days per year).

Table 8 Asset utilisation during transition cost parameters

Variant	Output	Category	Impact			
			2015-24	2025-34	2035-44	2045-54
Planned	Capital Cost	Heat Networks	-1%	-1%	-1%	-1%
Planned	Social Cost	Time saving (public and business)	£456,000	£456,000	£456,000	£456,000

Low and high values for the cost parameters were:

- Low: Capital cost: -0.5%; Social cost: £1,250/day (half the central value)
- High: Capital cost: -2%; Social cost: £5,000/day (twice the central value)

4.8 Bias towards incumbents

Description

In an unplanned future, acting in line with the status quo is more likely. Therefore, investment in district heating and electricity reinforcement will be delayed, and gas will serve more customers for longer.

We have not included this effect in the analysis due to the expectation that the Government would make changes to energy regulations which overcome the bias to incumbents, even in the absence of LAESs. The Government's Clean Growth Strategy, coupled with recent statements on the future of energy regulation, provide evidence to this assumption.

[30] ETI & AECOM 2017. Reducing the capital cost of district heat network infrastructure. Available online at https://d2umxnkyjne36n.cloudfront.net/teaserImages/Reducing-the-capital-cost-of-district-heat-network-infrastructure.pdf?mtime=20171103092304
[31] DfT 2018. Roadworks: the future of lane rental. Final Impact Assessment. January 2018. Available online at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/681460/lane-rental-impact-assessment.pdf

The other effects of this factor are dealt with by other drivers.

4.9 Other benefits not quantified in CBA

There are many other drivers that have not been captured in the current CBA. Two in particular have been included in the CBA model, but have not been populated with cost parameters:

- Retrofit costs: It is likely that energy efficiency retrofit costs would be higher under an unplanned future, since they would probably take place in multiple stages (e.g. fabric retrofit then heat pump retrofit comes later).
- Alternative policy target: Various local policy drivers could affect the cost-optimal outcome. For example, capital costs might be incurred to alleviate fuel poverty, but this would be additional to the cost-optimal case.

There is a related risk that in an unplanned variant there could be more retrofit than necessary thanks to the success of energy infrastructure decarbonisation. This represents a different actual outcome than the EPN optimal scenario and so has not been included.

Furthermore, simply producing a LAEP is likely to mitigate the risks of market shocks and stresses (e.g. collapse of gas customers). Without any further evidence, these benefits, and others, cannot be captured in the CBA, but they could be used to set a research agenda for future work.

5 Results

The table below presents a summary of the results from the Cost-Benefit Assessment calculation tool developed by Arup. The values are based on the parameters discussed in this report, and are calculated for the Bury area in Greater Manchester, based on the ESC's previous detailed work for that area.

The results indicate a very high benefit-cost ratio of local area energy planning. However, these numbers should be used with high caution: they are based on broad assumptions and with limited evidence to support them. They also relate to a single local authority location, and it cannot be said with any confidence whether Bury's optimal low carbon energy transition pathway is close to the statistical mean or an outlier. It is more appropriate therefore to consider these results as a test case of an approach to quantify the value of planning the energy transition at a local scale.

Table 9 Summary of results for 'central' sensitivity

Costs	**Unit**	**Unadjusted EPN**	**'Unplanned' Variant**	**'Planned' Variant**
Discounted Costs				
Capital	£m	3,471	4,351	3,113
Fixed	£m	330	340	330
Resource	£m	4,190	4,190	4,190
VOM	£m	96	96	96
Carbon Emissions				
Traded	£m	40	63	40
Non-Traded	£m	60	83	60
Additional Discounted Costs				
Social (Time)	£m	-	-	(1)
Cost of LAEP	£m	-	-	0.6
Net Cost				
Total	£m	8,185	9,122	7,827
Savings due to LAEP	£m			1,295

Table 10 Summary of results for ‘low’ sensitivity

Costs	Unit	Unadjusted EPN	‘Unplanned’ Variant	‘Planned’ Variant
Discounted Costs				
Capital	£m	3,471	4,137	3,292
Fixed	£m	330	339	330
Resource	£m	4,190	4,190	4,190
VOM	£m	96	96	96
Carbon Emissions				
Traded	£m	40	63	40
Non-Traded	£m	60	83	60
Additional Discounted Costs				
Social (Time)	£m	-	-	(0)
Cost of LAEP	£m	-	-	0.2
Net Cost				
Total	£m	8,185	8,908	8,007
Savings due to LAEP	£m			901

Table 11 Summary of results for ‘high’ sensitivity

Costs	Unit	Unadjusted EPN	‘Unplanned’ Variant	‘Planned’ Variant
Discounted Costs				
Capital	£m	3,471	4,677	2,755
Fixed	£m	330	342	330
Resource	£m	4,190	4,190	3,562
VOM	£m	96	96	96
Carbon Emissions				
Traded	£m	40	63	40
Non-Traded	£m	60	83	60
Additional Discounted Costs				
Social (Time)	£m	-	-	(2)
Cost of LAEP	£m	-	-	1.3
Net Cost				
Total	£m	8,185	9,451	7,469
Savings due to LAEP	£m			1,982

Table 12 Comparison of sensitivity results

	Unit	Low	Central	High
Total cost of unplanned variant	£m	8,908	9,122	9,451
Total cost of planned variant	£m	8,007	7,827	7,469
Difference between planned and unplanned variants	£m	901	1,295	1,982
Savings (% decrease over unplanned cost)	%	10%	14%	21%
Additional costs (% increase over planned cost)	%	11%	17%	27%

6 Findings and recommendations

6.1 Summary of findings

The foregoing discussion provides a framework and test case for defining the parameters of value of local area energy planning (LAEP) and of making an assessment of that value. Within the limitations of this commission, Arup has also provided a calculation framework in the form of an Excel cost-benefit assessment model; but it must be stressed that the assumptions which drive the numbers are inevitably broad and founded on limited evidence.

Further investigation is necessary to identify a stronger evidence base for each of the parameter values. Each parameter is a research topic in itself and is worthy of more extensive consideration.

Furthermore, the overriding assumption currently built into the calculations is that local area energy planning is the *sole cost* which will result in the significant reduction in costs compared with an unplanned situation. Further investigation is needed to reach a more complete estimation of the costs of local area energy planning, or to refine the attribution of impact to LAEP.

Nonetheless, these preliminary results provide a sense of the opportunity afforded by a well-planned future. Under the 'central' cost parameters, the total discounted savings in the Bury example were calculated to be £1,295m, well in excess of the cost of setting a decadal LAEP (<£1m). Indeed, the sensitivity analysis shows that despite a significant range in the total calculated discounted savings (£901m - £1,982m), these savings far outweigh the associated costs of setting the plan.

The results of the sensitivity analysis are summarised in Table 12. In this Bury example, where the total calculated discounted savings are of the order of £1-2bn, the savings represent 10-21% of the total costs of the unplanned variant. Viewed from another perspective, the additional costs of the unplanned variant against the planned variant are in the range of 11-27%.

Considered at a national scale, the combined opportunity across more than 400 local authorities appears to be extremely significant.

The cost savings shown here highlight the potential benefit of an effective local energy planning framework. It is important to note also that delivering the plan is only the first step. To realise the full savings, the local authority will require sufficient powers and sustained commitment of political leadership and staff resources in partnership with industry, stakeholders and citizens to implement the plan.

6.2 Next steps

Arup recommends that the following steps are taken in relation to determining the cost-benefit assessment for local area energy planning:

- Conduct further literature review and analysis to identify evidence for the value of planning, and to provide more robust factors for the parameters of value identified within this study.
- Engage with key stakeholders who can advise and debate the costs and benefits of planning. These stakeholders should include practitioners and representative bodies from utility, local government, construction and academic sectors.
- Investigate or model the full costs of LAEP, beyond the initial stage of produce the evidence and making the plan.
- Develop a more detailed conceptual model of how local area energy planning would be implemented across the country which takes account of local government statutory powers and responsibilities. In particular, the question of whether local area energy strategies will be voluntary or mandatory, and what will be their statutory weight, will have an important bearing on their actual impact on energy investment and behaviour.