EnergyREV

DEVELOPING AN ORGANISING FRAMEWORK

How do we create successful smart local energy systems?

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About this document

This document is the result of discussions and feedback from across the EnergyREV consortium. While it represents a broad consensus position, it is important to note that this does not mean that it reflects fully the views of every member of the consortium.

The coordination and writing of this document were led by Michael Fell (University College London) for EnergyREV work package 5.1. Chris Maidment, David Shipworth, and Carol Vigurs (University College London) from the WP 5.1 team supported and reviewed the report.

The ideas in the work are derived from the contributions of EnergyREV researchers, for which we are very grateful. The EnergyREV consortium coordinators, work package leads and roving champions who were involved in this work are:

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- Walter Wehrmeyer | University of Surrey
- Mercedes Moroto-Valer | Heriot-Watt University
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For a full list of participating researchers, please visit www.energyrev.org.uk.

1 Introduction

A central objective of the Prospering From the Energy Revolution (PFER) programme is to understand how smart local energy systems (SLES) could support prosperous communities across the United Kingdom, through means such as cutting bills, creating jobs and attracting investment. This is a large and highly complex societal project. In EnergyREV, we are developing a high-level Theory of Change to help give structure to our thinking about how such systems might emerge, and how they will yield the intended impacts. This brief report explains:

- The Theory of Change approach
- Describes the process by which the provisional Theory of Change was arrived it
- How the Theory of Change is organised
- How it will be used and built upon by EnergyREV researchers in future work.

A separate document [LINK] provides a set of worksheets, based around the Theory of Change, intended for use by organisations involved in developing and implementing SLES.

2 Theory of Change approach

2.1 Background

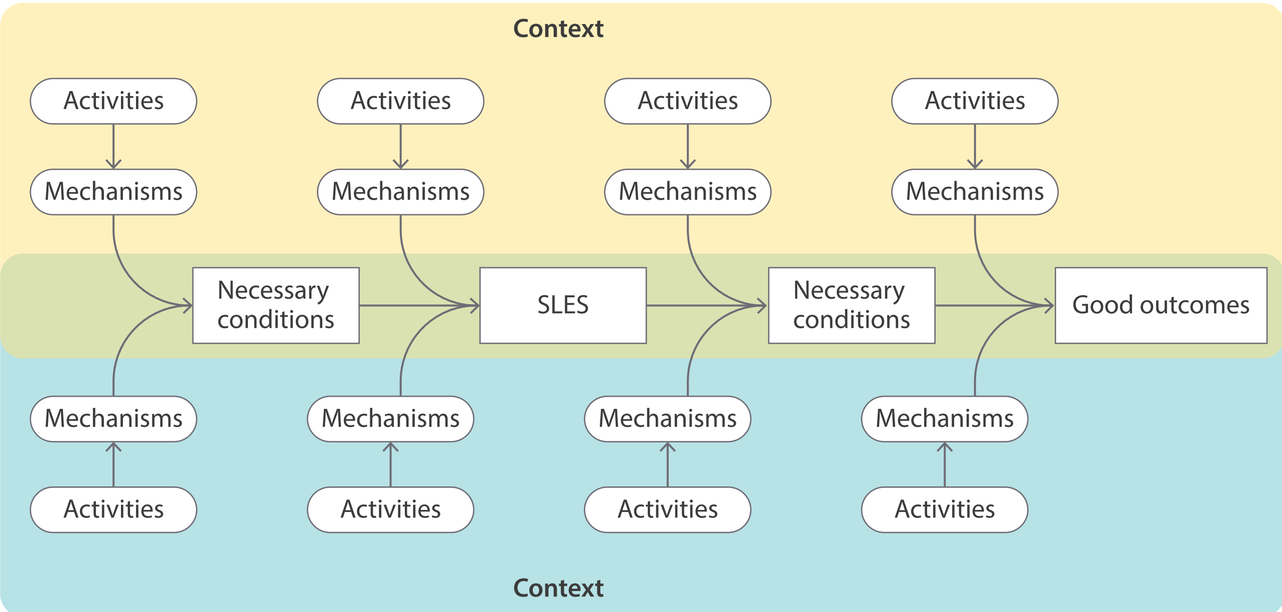
While local energy is not a new concept, genuinely smart and local energy systems are still rare in the UK and other countries which have mature, centralised energy systems. Those in operation have come about under very specific circumstances and cannot simply be copied and pasted into other localities and either function or deliver the desired outcomes. There is no clear blueprint for what will work, for whom, under what circumstances, and how.

EnergyREV work package 5.1 (interdisciplinary knowledge synthesis) employs a realist review (or synthesis) approach to maximising the value we can gain both from existing evidence, and that emerging from other EnergyREV work packages. Realist review systematically explores evidence to help understand the mechanisms by which particular interventions lead to outcomes, and what about the context for those interventions meant that these particular mechanisms and outcomes occurred.[1]

Focusing on the interaction between context, mechanism and outcome is particularly useful for understanding more complex systems where the same actions are not expected to have the same effects in all circumstances (Figure 1).

For example, user participation could be an important condition for an SLES. There are many possible activities that could achieve this, including running a local billboard marketing campaign, introducing it as a default option for new social housing tenancies, or running town hall discussion and sign-up meetings. These might all work in different ways, and with differing results in different places.

Figure 1: Abstract representation of how different activities are needed in different contexts to create the conditions for SLES to emerge, and for good outcomes to result.

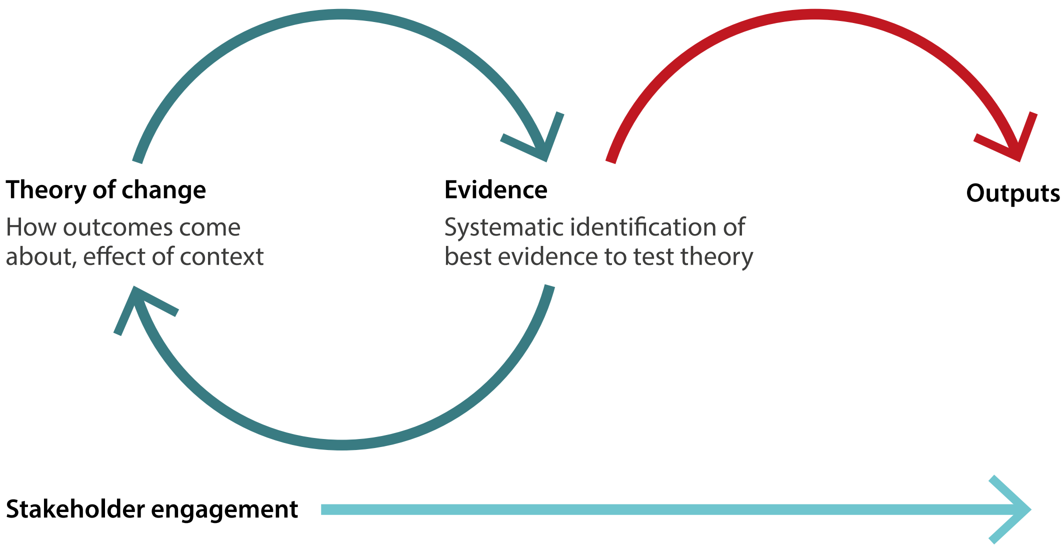


1 Pawson et al. 2004. Realist synthesis: an introduction. ESRC Research Methods Programme Working Paper Series, August 2004.

Realist review starts from the position that if a programme of activities is planned to achieve certain goals, such as introducing SLES to support prosperous communities across the UK, there must be an underlying expectation about how one will lead to the other. We use the terminology Theory of Change (ToC),[2] the story that is told about how a programme will work, and (ideally) for whom and under what circumstances. The review tests this view of the world against the available evidence, for example from previous research projects or case studies. The evidence may back up the ToC, require it to be amended, or even undermine it entirely. Or, if there is no evidence, parts of the ToC must remain provisional until such time as evidence begins to be generated. The process is summarised in Figure 2.

The ToC gives structure to the early stages of the review, making it easier to decide where to focus searches, extraction or findings, and so on. Later stages of the review can be redirected on the basis of evidence that is uncovered. The provisional ToC can be constructed on the basis of an initial light-touch literature review, and/or engagement with expert stakeholders.

Figure 2: Basic representation of the role of the ToC in the realist review process.



The advantage of the latter approach is that drawing out the ToC can play an important role in ensuring that, as far as is possible, all parties are working from a similar initial understanding of the potential effects of a programme. It provides an early opportunity to check whether relevant stakeholders hold different assumptions about how change might come about. Given the advantages of an engagement-based approach, we developed the EnergyREV ToC collaboratively across the consortium.

2.2 Developing the EnergyREV Theory of Change

Our provisional ToC was constructed collaboratively by EnergyREV work package leads and researchers. We held initial meetings with work package researchers from an array of disciplines including engineering, sociology, geography, business and regulation. We discussed what they viewed as the most important factors, from the point of view of their subject, in whether SLES would emerge as an outcome, the assumptions underpinning this, and the main, most likely risks. On the basis of these meetings, we constructed 'sub-ToCs' for each specific work package representing the pathways to outcomes. These were reviewed and amended by the relevant researchers.

2 Blamey, A. and Mackenzie, M. 2007. Theories of change and realistic evaluation: peas in a pod or apples and oranges? *Evaluation*, **13**(4): 439-455.

These sub-ToCs formed the basis of a workshop attended by approximately 30 researchers, held at the EnergyREV annual assembly. Researchers had the opportunity to comment on and amend both their own sub-ToCs, and those of other work packages. They were also encouraged to highlight important connections between different work streams, as well as any major omissions. The sub-ToCs were combined into a full ToC, representing the EnergyREV 'story' for developing successful SLES. Some further structural alterations were made (see next section), again reviewed by EnergyREV members, and the provisional ToC finalised.

3 The provisional EnergyREV Theory of Change

Due to its size, the diagrammatic representation of the provisional ToC is separated into 4 images which link together (see page 7). We have also created tables summarising its main aspects (see page 14), which is shown on the following pages. The main positive outcomes captured in the ToC are:

- Sufficient decarbonisation of the energy system
- Attracting investment
- Supporting prosperous communities across the UK.

In this context, a prosperous community is one where bills are affordable, levels of comfort, health and wellbeing are high, there is sufficient high-quality local employment and natural ecosystems are thriving.

Introducing successful SLES across the UK would be a substantial and complex societal project. The ToC does not yet go into specific detail on the activities and mechanisms required to foster this transformation, it focuses on relatively high-level 'necessary conditions' which must exist for thriving SLES to materialise. As far as possible, we have included conditions that would apply across all (or almost all) contexts – considerations that will become much more important when we take into account specific activities, mechanisms and outcomes (see Figure 1).

The ToC is arranged in 'challenge areas' which we consider to be necessary conditions, and which experts across disciplines believe are the most important to address. These areas are not mutually exclusive (indeed they are highly interactive), but provide a useful way of breaking down the overall project into more tractable sub-elements. The challenge areas are collected by theme into a number of 'layers': digital; people and organisations; services; and whole systems. We have not yet included a challenge area on the critical issue of policy and governance; we view this as a set of activities which may contribute to, or limit, the possibility of creating the necessary policy conditions.

The second column of the table, and all boxes to the left of the blue centre line in the diagram, presents the necessary conditions for SLES to emerge. The third column, and boxes to the right of the centre of the diagram, show the necessary conditions for specified good outcomes. The fourth column, indicated by "A:" in boxes on the diagram, sets out the main assumptions which must be met if the necessary conditions are to foster the emergence of successful SLES. For example, a possible outcome of SLES is that they provide a route to increasing local high-value employment. However, this is based on the assumption that SLES do create significant employment opportunities – this assumption may be wrong and should be tested. The final column of the table (and red boxes on the diagram) sets out the main risks we believe to be associated with the emergence of SLES.

In addition to the challenge-specific conditions, assumptions and risks set out in the ToC, we also include a number of general assumptions, along with highlighting important contextual dimensions. For example, underpinning the ToC is an assumption that SLES are a better way of achieving good outcomes than larger scale approaches – we have not taken into account that this may not be the case. However, we will be testing these assumptions against the available evidence in the course of our future review work.

The contextual dimensions were identified during the ToC workshop, and show what are likely to be amongst the most important contextual factors determining what sorts of outcomes are likely to be afforded by an SLES, and which particular approaches might be best suited to achieving them.

General assumptions

- That benefits of local approaches outweigh those of larger scale approaches.
- That there is widespread access to basic enabling technology, for example, smartphone, broadband.
- There is increased adoption of renewable energy and energy storage technologies.
- Lessons on (un)successful SLES are effectively shared.

Key contextual factors

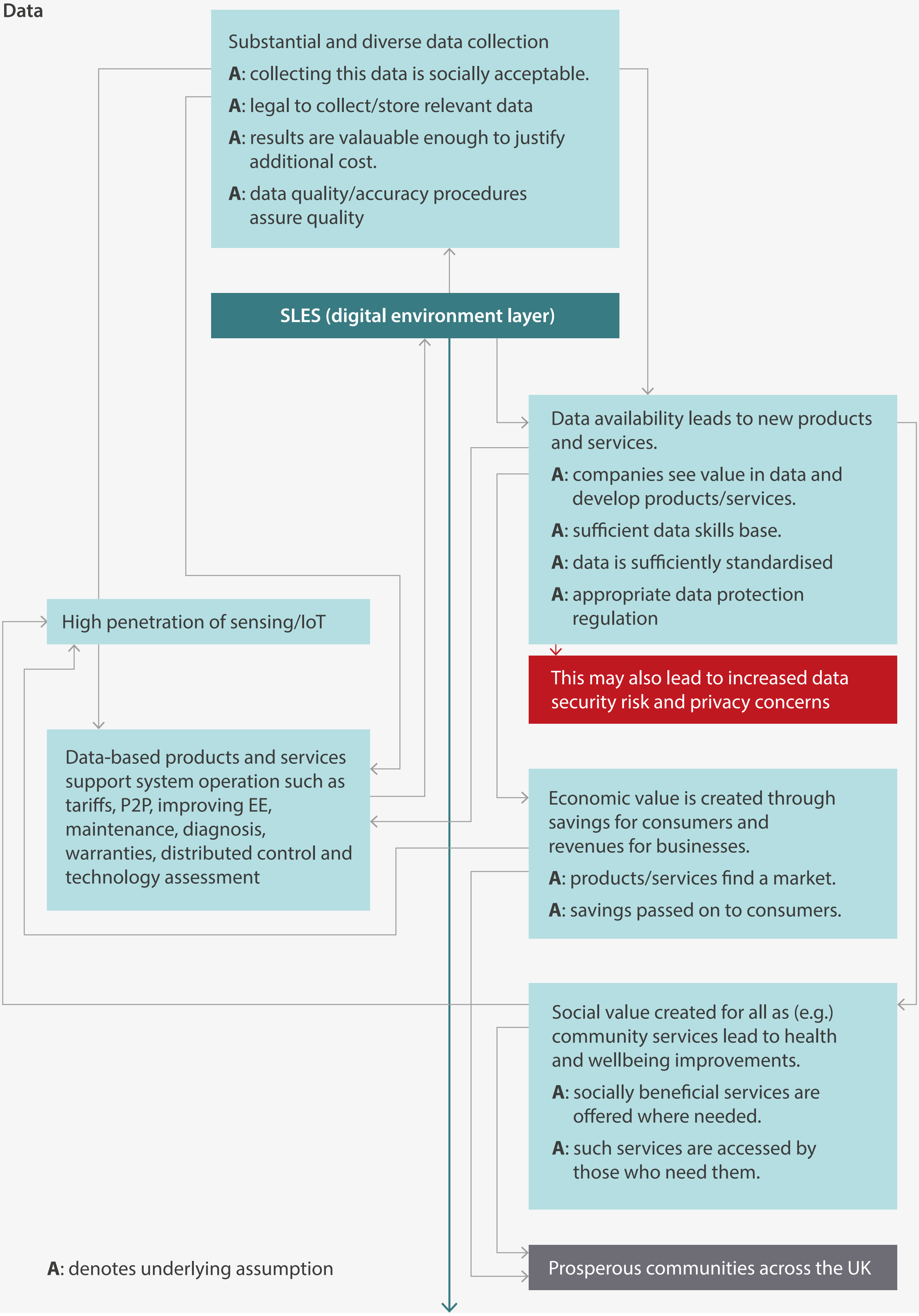
- Local energy resource capacity – physical, including terrain type.
- Local skills base.
- Existing communities of interest and prior experience, cohesive community.
- Demographic factors, including economic, employment.
- Infrastructure – energy i.e. capacity, but also broadband, transport, building stock etc.
- Local governance – type, approach, capacity.

Prosperous community

A prosperous community where bills are affordable, levels of comfort, health and wellbeing are high, there is sufficient high quality local employment and natural ecosystems are thriving.

Digital layer

Data



People and organisations layer

Users

SLES developers have capacity (and plan) to incorporate user participation

A: Sufficient skills

SLES users have opportunity over time to participate in planning

SLES users have opportunity to participate in project design

Design omits interests of certain groups, and they miss out on benefits

Resistance campaigns and/or apathy

SLES services planned with, not simply delivered to, users

Local users choose to participate in SLES services

Participation may be more difficult for some than others due to lack of access to enabling/flexibility technologies e.g. EVs

Skills

Organisations offer courses / training in skills relevant to SLES

A: a transition towards SLES is broadly known about

A: such skills are seen as desirable and training is attractive

Certification schemes allow people to evidence skills and assure quality of work

People with appropriate backgrounds recognise the applicability of their skills to SLES

People participate in training.

A: people are aware of training

A: people aware of types of opportunities SLES offer and find them attractive

A: policy stability gives people assurance that new skills will be valued

A: people can afford training

Skilled users (e.g. energy champions) present to support grass roots engagement and organisation

Workers with skills relevant to the design, operation, maintenance of SLES are present locally, as well as those with general skills such as communications, facilitation, project management, entrepreneurship etc.

Business and finance

Public loan guarantee and other policy measures.

A: objectives for loans aligned with local objectives.

Successful projects prove that SLES are a good investment (note: a 'good investment' means different things to different actors).

A: success can be evidenced in a persuasive way.

Affordable finance is available for SLES.

A: innovative routes to financing exist.

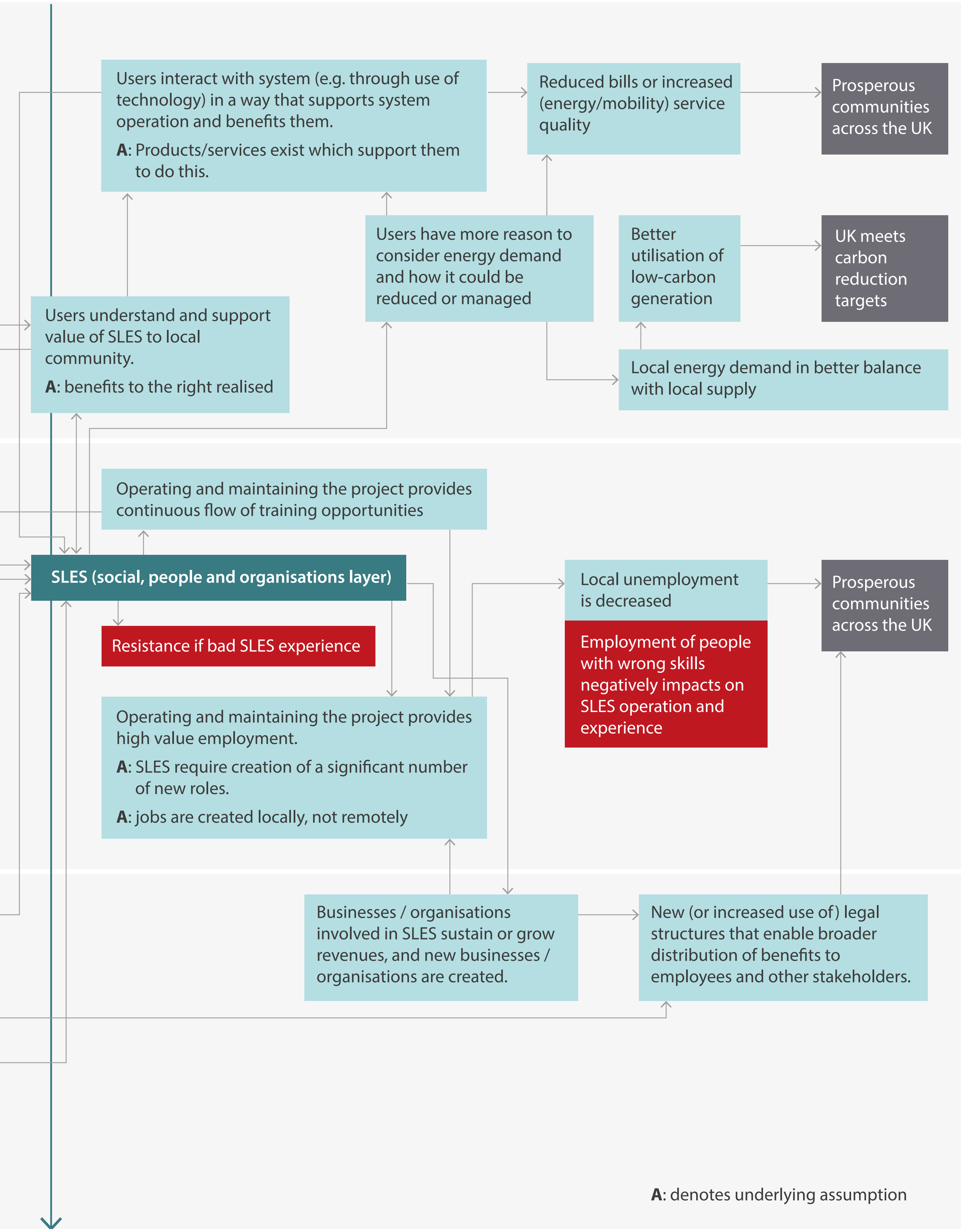
A: reg/policy certainty

Organisations collaborate to conceive and design SLES.

A: companies are willing to collaborate.

Optimal outcomes for project could be (or be perceived as) sub-optimal for individual companies

Feasibility study shows the project to be feasible



A: denotes underlying assumption

Services layer

Heating & cooling

There is broad awareness of the importance of heating and cooling as a contributor to UK GHG emissions

Organisations are aware of types of heating and cooling solutions at different levels of scale

Organisations understand need for balance between automation and user participation, especially with regard to heating/cooling.

A: sufficient skills

Appropriate regulation is introduced for heating/cooling and its automation, and managed over time

Over-regulation stifles innovation in the sector

Organisations develop heating/cooling products and services that support SLES development or operation (at appropriate scale).

A: High-volume low-cost transaction platform available

A: These products are attractive to and taken up by users

Mobility

Products and services (such as tariffs and marketplaces) are available to incentivise and coordinate EV charging

Increased penetration of EVs with smart charging and V2G capability

A: interoperable EV charging

Continued congestion

Displaced active transport, so missing health benefits

Effective local grid balancing and other services

A: users participate in smart charging/V2G.

A: acceptable vehicle reliability

A: permitted under regulation

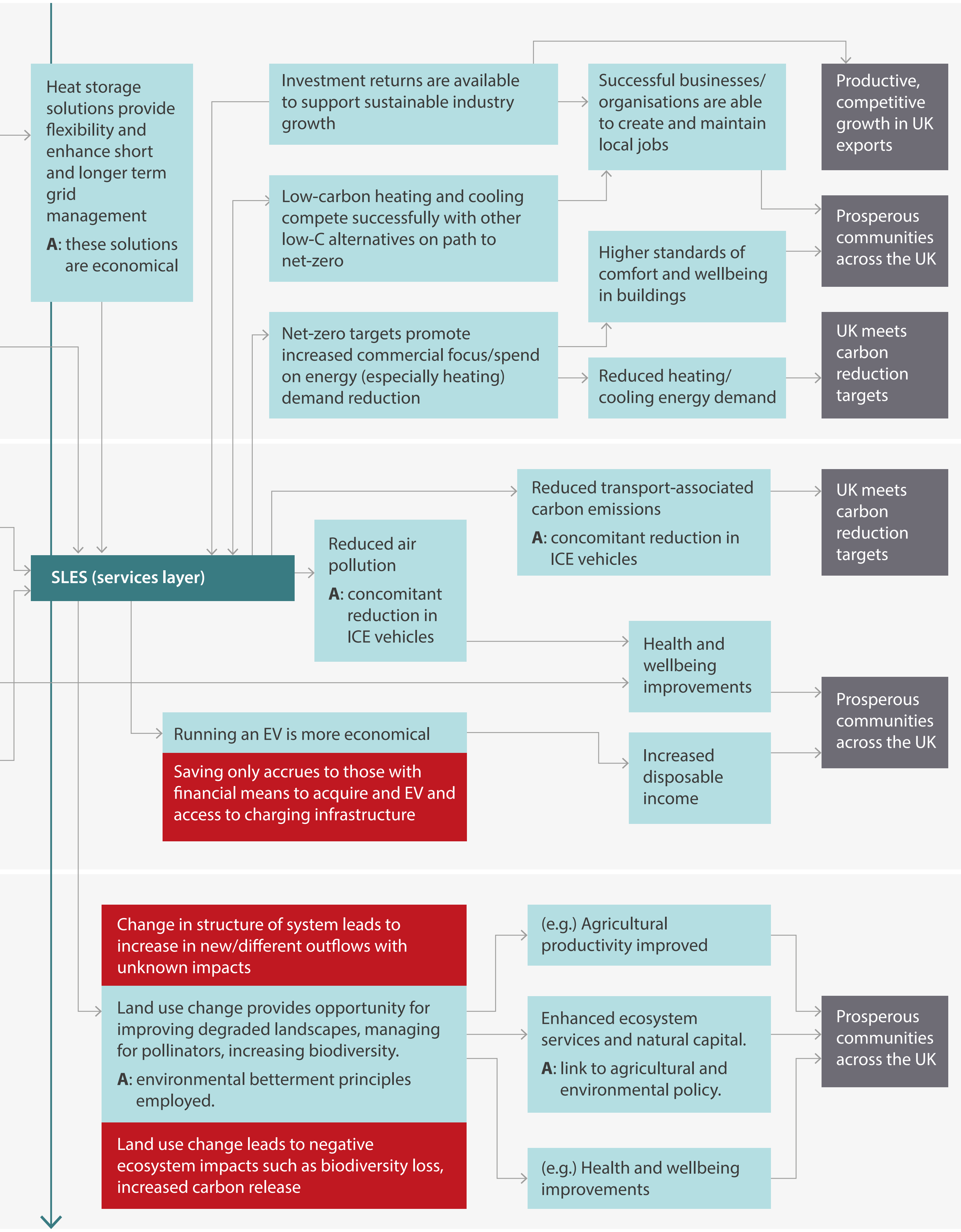
Displacement of (potential) EVs by active transport modes reduces (potential) local electricity demand, making it more easily meetable through local generation

Less capacity to provide grid services

Less new generation required to make SLES which can meet meaningful proportion of local demand

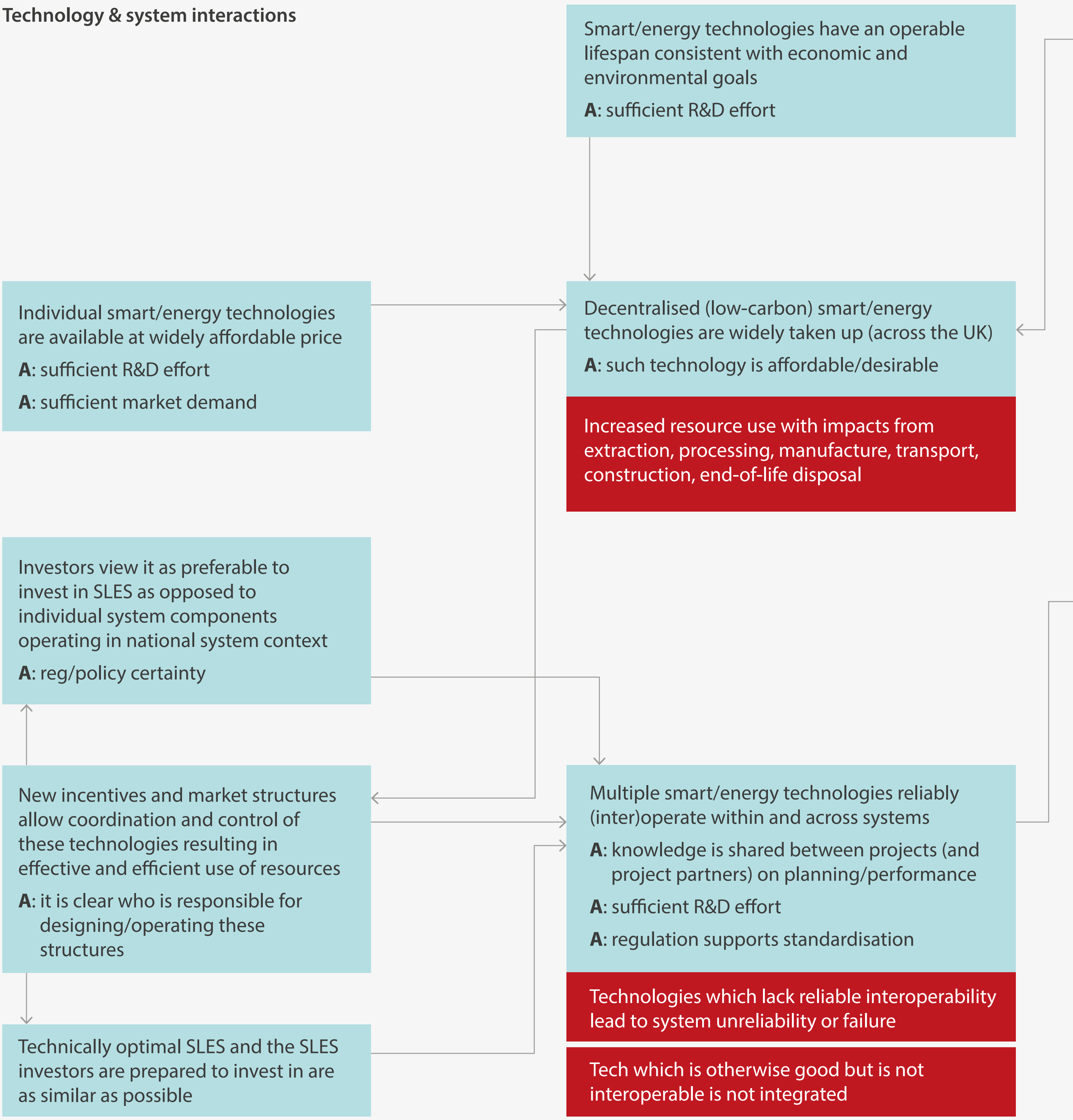
Ecosystems

A: denotes underlying assumption

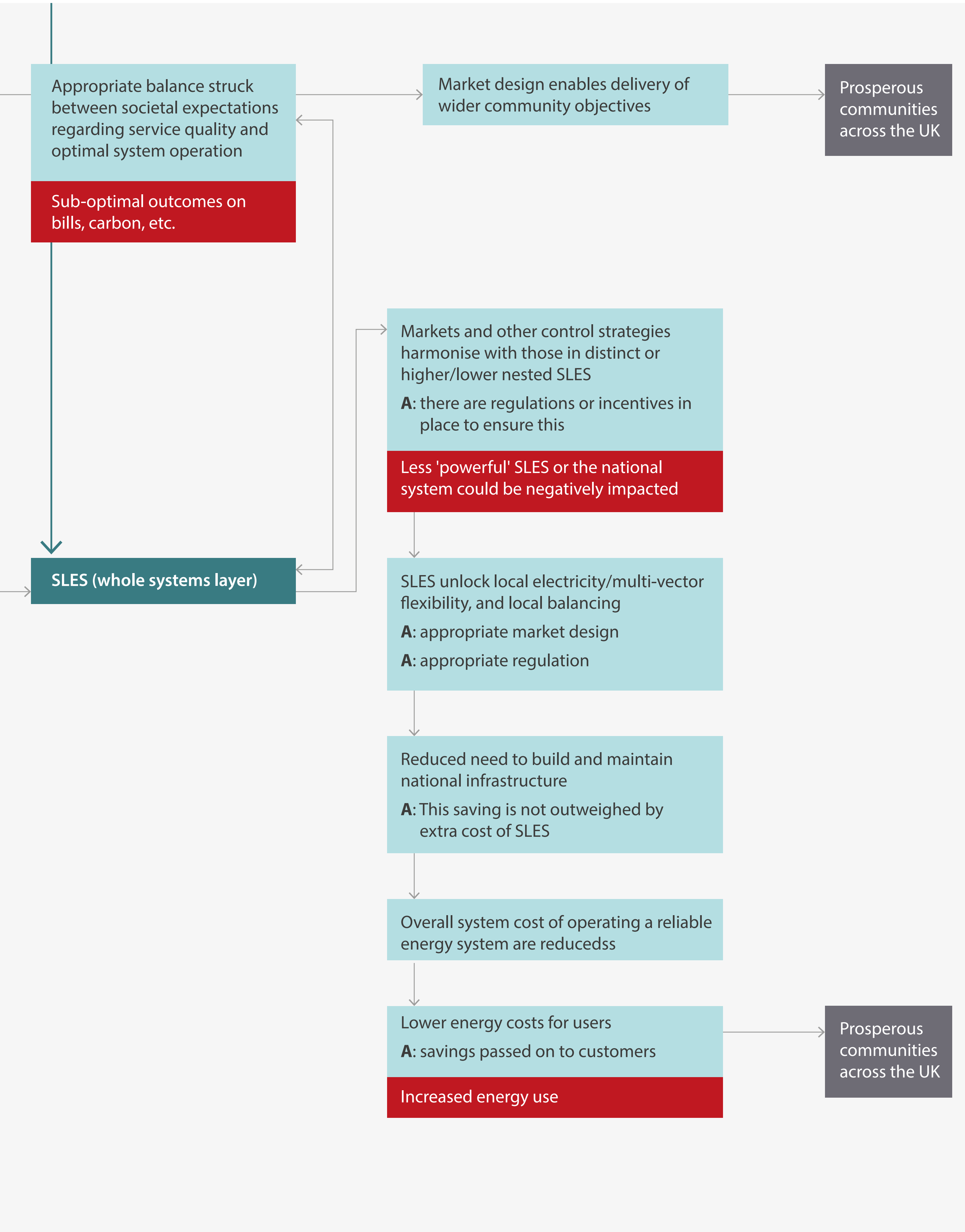

Heat storage solutions provide flexibility and enhance short and longer term grid management
A: these solutions are economical
Investment returns are available to support sustainable industry growth
Successful businesses/ organisations are able to create and maintain local jobs
Productive, competitive growth in UK exports
Low-carbon heating and cooling compete successfully with other low-C alternatives on path to net-zero
Prosperous communities across the UK
Higher standards of comfort and wellbeing in buildings
Net-zero targets promote increased commercial focus/spend on energy (especially heating) demand reduction
Reduced heating/ cooling energy demand
UK meets carbon reduction targets
Reduced transport-associated carbon emissions
A: concomitant reduction in ICE vehicles
UK meets carbon reduction targets
SLES (services layer)
Reduced air pollution
A: concomitant reduction in ICE vehicles
Health and wellbeing improvements
Prosperous communities across the UK
Running an EV is more economical
Saving only accrues to those with financial means to acquire and EV and access to charging infrastructure
Increased disposable income
Change in structure of system leads to increase in new/different outflows with unknown impacts
(e.g.) Agricultural productivity improved
Land use change provides opportunity for improving degraded landscapes, managing for pollinators, increasing biodiversity.
A: environmental betterment principles employed.
Enhanced ecosystem services and natural capital.
A: link to agricultural and environmental policy.
Prosperous communities across the UK
Land use change leads to negative ecosystem impacts such as biodiversity loss, increased carbon release
(e.g.) Health and wellbeing improvements

Whole system layer

Technology & system interactions



A: denotes underlying assumption



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Digital layer	
Challenge area	**Data**
Necessary conditions for SLES	High penetration of sensing/Internet-of-Things leads to substantial new data collection. Products and services are developed which support SLES operation (e.g. tariffs, peer-to-peer trading, improving energy efficiency, maintenance, diagnosis, warranties, distributed control and better technology assessment).
Necessary conditions for good outcomes	New products and services create economic value through savings for consumers and revenues for business. Social value is created as community services lead to health and/or wellbeing improvements.
Main assumptions	Necessary data collection is socially acceptable and appropriately regulated. Organisations perceive the results as valuable enough to justify the additional costs of data collection, and to develop products which are then taken up. Processes are in place to ensure sufficient data quality and interoperability. Savings are passed on to users, and services are offered to, and accessed by, those who most need them.
Risks	Data security and privacy concerns.

People and organisations layer	
Challenge area	**Users**
Necessary conditions for SLES	Local domestic and non-domestic users participate in SLES (as users, but also project/service design if they wish), and understand, support and in some cases champion the value of SLES to community.
Necessary conditions for good outcomes	Users interact with SLES in a way that both supports system operation and benefits themselves. Reduced and flexible demand leads to better local balancing, contributing to reduction of carbon emissions and network costs, and lower bills.
Main assumptions	There is (or can be) appetite amongst users to get involved in SLES planning, and developers have the skills and incentives to accommodate this. Products/services allow users to support SLES operation and their own needs.
Risks	Design of SLES/processes omits interests of certain groups, meaning they miss out on benefits, and reducing support for SLES with the potential for resistance campaigns. This may include lack of access to generation, storage or flexibility technologies.

Challenge area	Skills
Necessary conditions for SLES	Workers with skills relevant to design, operation and maintenance of SLES have been trained and are present locally. There is also sufficient supply of those with general skills (e.g. communications, facilitation, project management).
Necessary conditions for good outcomes	Operating and maintaining SLES provides reliable, local high-value employment and training opportunities, reducing unemployment and increasing earnings.
Main assumptions	SLES are known about, and people know what skills are needed and have confidence they will be valued on an ongoing basis. Training is known about and accessibly priced. SLES create significant new work opportunities, especially locally.
Risks	Prioritising employment of local people but with wrong skills negatively affects SLES performance. If SLES do not happen locally or elsewhere, certain skills may not be needed.

Challenge area	Business and finance
Necessary conditions for SLES	Organisations collaborate to conceive and design SLES, which passes feasibility study. Affordable finance is available to organisations seeking to develop SLES solutions.
Necessary conditions for good outcomes	Organisations involved in SLES sustain and grow revenues, and new businesses are created, including those with legal structures that benefit employees and other stakeholders. Local employment is increased.
Main assumptions	Innovative routes to financing exist that are consistent with local needs, and there is policy (and other) certainty regarding future of SLES. Evidence of previous success is accessible and persuasive. Organisations are aware of SLES opportunities and willing to collaborate with each other.
Risks	Optimal outcomes for SLES may be suboptimal for individual elements.

Service layer

Challenge area	Heating and cooling
Necessary conditions for SLES	Organisations develop heating/cooling-related products and services that are taken up by users and support SLES operation, such as through storage and demand flexibility/reduction.
Necessary conditions for good outcomes	Investment returns support sustainable industry growth, as low-carbon heating/cooling competes successfully. Net zero targets increasingly prompt greater household/commercial spend on energy demand reduction, reducing carbon emissions and improving comfort and health.
Main assumptions	Broad awareness of importance of heating/cooling in low-carbon transition, and organisations are aware of the different solutions available. Low-carbon products/service options are attractive to users and easy to access and use (balancing automation and user involvement). Regulation allows innovation while protecting users.
Risks	Regulation either stifles innovation, or allows diffusion which outpaces the ability of energy system infrastructure to adapt. Certain users are unable to access new products/services and miss out on benefits. Inescapable service contracts charge users too much or allow poor quality service.

Challenge area	Mobility
Necessary conditions for SLES	Increased penetration of electric vehicles supports effective local grid balancing, aided by products/services such as local flexibility tariffs and markets. And/or increased reliance on active transport reduces local energy demand, making it easier to cover local demand from local generation (while reducing capacity to provide flexibility services).
Necessary conditions for good outcomes	Mobility-related carbon emissions are reduced as internal combustion vehicles decrease, which also leads to reductions in air pollution and related health improvements. These are also supported by increased use of active transport. Lower mobility costs increase disposable income.
Main assumptions	EV charging infrastructure is broadly interoperable. Participating in smart charging and/or vehicle-to-grid (V2G) services provides acceptable levels of vehicle reliability, consistent with user adoption.
Risks	Electrification of transport does not address congestion or road safety, and displaces active transport, so reducing health and wellbeing benefits. However, limited storage capacity provided by EVs constrains local flexibility potential. Savings/income only accrue to those who are able to access EVs.

Challenge area	Ecosystems
Necessary conditions for SLES	Land use change (e.g. for solar farms) provides an opportunity to improve degraded landscapes, manage for pollinators, increased biodiversity, etc.
Necessary conditions for good outcomes	Enhanced ecosystem services and natural capital. This includes improved agricultural productivity, and health improvements through access to attractive environments and reduced pollutants.
Main assumptions	Environmental betterment principles are applied in planning and development.
Risks	Energy system changes lead to increase in new/different material outflows with unknown impacts. Unsustainable resource use associated with extraction, processing, manufacture, transport, construction, end-of-life disposal. Land use change without environmental betterment leads to habitat loss, carbon release.

Whole system layer	
Challenge area	**Technology and system interactions**
Necessary conditions for SLES	Widely adopted smart/energy technologies reliably interoperate within and across SLES, unlocking local and multi-vector flexibility.
Necessary conditions for good outcomes	Markets and other control strategies harmonise with those in distinct or higher/lower nested SLES, reducing new infrastructure requirements, operating costs, and bills.
Main assumptions	Smart/energy technology is accessible/desirable, with sufficient operable lifespan. Regulation supports component and system interoperability. Investors invest in systems rather than (just) individual components, and responsibility for system design/operation is clear. Investment and societal priorities align with optimal SLES outcomes. Regulation, incentives and market design ensure outcomes are better for individual SLES if they do not conflict with each other.
Risks	Interoperability challenges mean individually effective technologies cannot be integrated and provide benefits, or disrupt the system. Less 'influential' SLES areas are negatively impacted. Savings in overall system costs lead to rebound effects which increase energy use.

4 Using the Theory of Change

We are using the ToC to help structure our ongoing review work. We are looking for evidence to support the importance of the necessary conditions that we identified, and on the actions and mechanisms that might bring them about under different circumstances. We will update the ToC to reflect the existence or absence of such evidence, and extend it where research suggests there are important areas that are not currently captured. Another EnergyREV initiative is underway to create, through a user-centred design approach, an interactive interface that will allow stakeholders to easily identify and access the evidence which is important to them. We are also working closely with the EnergyREV team exploring evaluation approaches to ensure that the measures of success identified for SLES can be usefully mapped onto the ToC.

We believe the provisional ToC has immediate value for stakeholders. It reflects the views of experts across a diverse range of subjects, and provides a solid starting point for thinking about the sorts of activities that might need to be undertaken to deliver successful SLES. For example, those commissioning or developing an SLES might consider whether their plans are likely to meet all the necessary conditions, and how. If not, is this because they reject the need for the condition, or for other reasons? A policymaker, on the other hand, might consider where the policy/regulatory landscape is consistent with maximising the chances of the necessary conditions coming about, and how the landscape might need to change to achieve this. A set of worksheets will help to guide stakeholder discussions, which is available on the following pages.

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About EnergyREV

EnergyREV was established in 2018 (December) under the UK's Industrial Strategy Challenge Fund Prospering from the Energy Revolution programme. It brings together a team of over 50 people across 22 UK universities to help drive forward research and innovation in Smart Local Energy Systems.

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