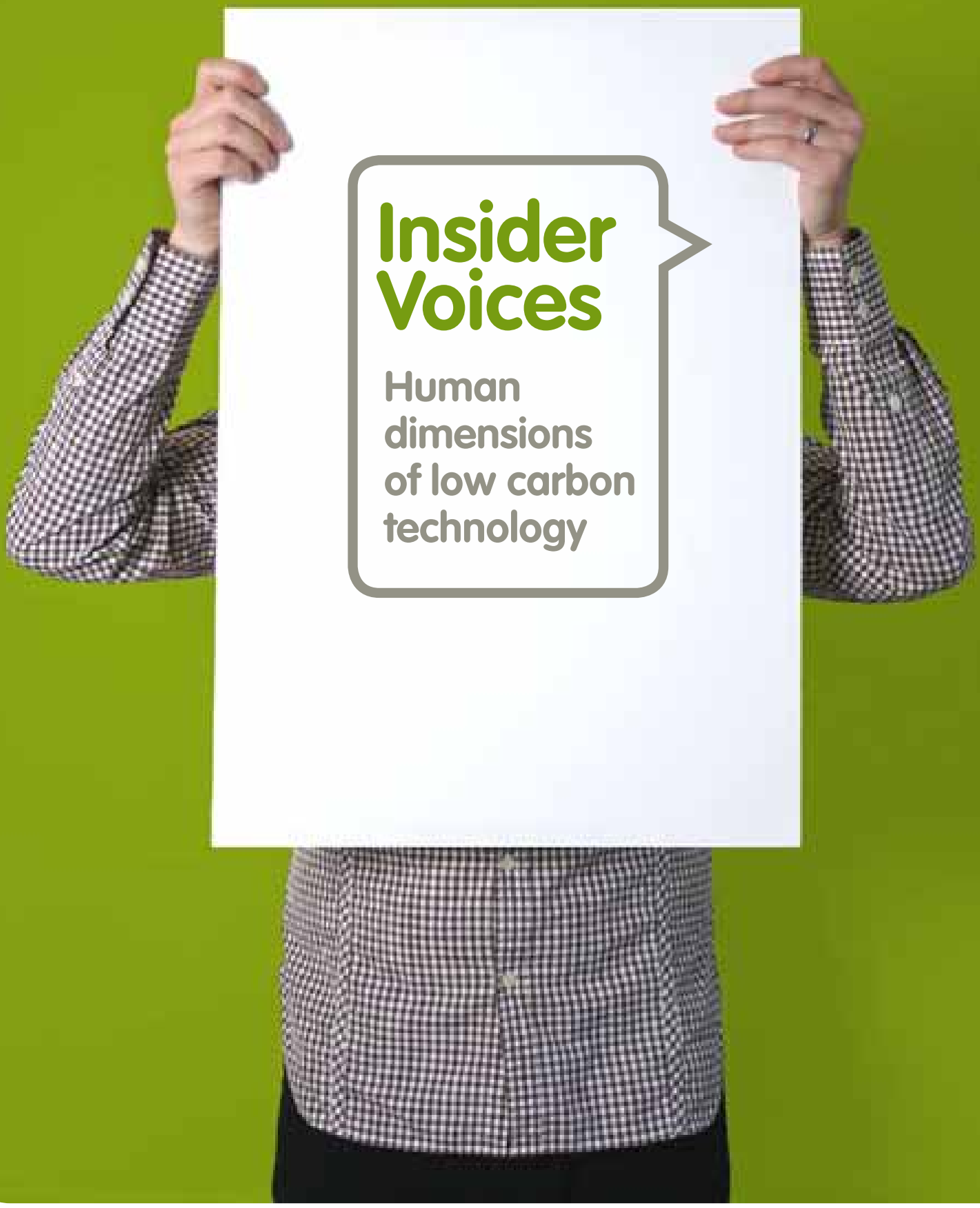
lowcarbonworks
unlocking sustainable futures



Insider Voices

Human dimensions of low carbon technology

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Please also see www.lowcarbonworks.org.uk

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Designed by Positive2.

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EPSRC Engineering and Physical Sciences Research Council
University of Bath
CARPP Centre for Action Research in Professional Practice
E·S·R·C Economic & Social Research Council
University of Bristol
Manchester

Insider voices: Human dimensions of low carbon technology

There are many things to do to bring about a sustainable world… Whatever you do, do it humbly. Do it not as an immutable policy, but as an experiment. Use your action, whatever it is, to learn.
Meadows et al, 2004

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How to read this report

For over five years, we have been exploring one of the important routes to a low carbon future: what is it that encourages and inhibits the adoption of low carbon technologies by business and local authority organisations? This report gives an account of our exploration which we hope will be of practical interest to organisations, to policy makers, to those undertaking research and those who fund such research.

Document key

Direct quote

Publicly available material

Researcher reflection

Link to ingredient for low carbon change

Link to theory and tools

Link to narrative

Key also available on back cover flap

We have designed this report to be read in different ways by different audiences. You can read from start to finish, beginning with the framing introduction and action research methodology outline, then the narratives, on to the theory and finally to tools and recommendations. However, you may prefer to find your own way through in a different order.

You could get straight into the thick of it with one or more **Narratives** or **Insider Voices**. As action researchers we have attempted to get as 'close to the knitting' as we can, working with people involved in the strategies and implementation of a lower carbon pathway, at every organisational level. Each narrative contains boxes which cross reference to theories and tools, and highlight our own reflections as researchers.

The narratives may lead you to look more closely at **Theories**. When people talk about reducing carbon emissions, they usually talk about technologies or economics. There is a common assumption that innovation moves from basic research to applied research to technology development and diffusion. But recent research and theorising shows this model is misleading. Innovation does not take a straight line path like this, and at least two other issues are of crucial importance in low carbon initiatives: the wider systemic context in which the initiative is situated, and the human relationships that build capacity to drive the innovation. We offer summaries of key theories and link these back to the narratives to show them in practice. This is not a formal academic literature review, but written for a lay audience, although we have provided additional references for further reading.

Our theory section is closely related to **Tools**, where we offer two different ways to consider what it takes for an organisation to move along a low carbon path. The **complementarities matrix** provides a systematic map for assessing the alignment or otherwise of diverse opportunities for change. The **organisational responsiveness** framework provides a way of assessing the capacity and readiness of an organisation to respond to the challenges of a low carbon future.

You may of course go straight to our **Recommendations.** We have drawn together narratives and theories to propose **Ten ingredients for low carbon change** in organisations and **Key issues for policy makers and research funders**. We very much hope that if you start here you will be drawn back to some of the narratives, because there is so much to be learned from how each situation uniquely unfolds.

We have provided a key which shows how the various sections link (opposite and on fold out flap on back cover); a general and a technical glossary and references to further reading.

Introduction

If people within regimes resist regime change, whether consciously or not, and if the landscape is largely resistant to conscious attempts to change it, where does transformative change most often begin?

Introducing the Lowcarbonworks project

As often with research – and life – we have not ended up where we expected. The original aim of the Lowcarbonworks project was to explore what it was that enabled and hindered the adoption of low carbon technologies. We wanted to work closely with people in business organisations (to which we soon added local authorities); with academics developing low carbon technologies; and with economists to explore the relationship between the broad sweep of technological development and investment cycles and the detailed day to day management practices involved in introducing low carbon technologies in organisational contexts.

We were sure that the development of a low carbon future was more than a technological issue and that there would be an important relationship between macro trends – technological, economic and political – and micro practices of managing change. We proposed that moments of potential transformation exist in the wider economic and technological context and we wanted to learn how to seize and respond to such moments in a creative fashion.

In retrospect, what we set out to do was hugely ambitious and difficult to achieve in practice. However, our project has been enormously fruitful, even with a less ambitious scope. We have seen at close hand the intricate relationships between a variety of opportunities for low carbon change and the responses of organisations at formal and informal levels. We have had the privilege of being close to major projects where significant carbon reductions have been achieved; and we have witnessed the struggles and difficulties of skilled and well-intentioned people to make change where conditions are unfavourable.

In this report we offer accounts of what we have learned about noticing, understanding and working with the unique and distinctive qualities of each low carbon technology project. No theoretical model can do justice to the unique set of social, organisational, technological and economic factors at play in a particular change environment at a particular time.

We review some current theories which explore technological change; and we bring other theories which have helped us understand the more intimate details of working for low carbon change. We provide stories of the projects we have explored to knit the theory back into actual practice, and bring to life the distinctive qualities of each situation. These narratives are not simply 'case studies' or abstract 'best practice'. They are lively records of the insider voices – practitioners and researchers – in the thick of the action, trying to make low carbon change happen as best they can. We offer some general learning and guidelines for those engaged in low carbon initiatives; and also for policy makers and research funding bodies.

Research assumptions

We set out on this research with five core assumptions:

1) **The barriers to a low carbon economy are not primarily technological.** Contextual issues – economic, political, organisational – will always be important.

2) **Technological, economic and human factors are systemically interlinked.** Systems are 'locked in' so that changing one factor has limited impact; but addressing several at the same time may result in a virtuous cycle of change.

3) **Significant human factors in enabling change include awareness of the issues, membership of a community of practice, and a sense of agency.** People often feel powerless in the face of the enormity of climate change so it is important to build capacity to act at individual and collective levels.

4) **There are fleeting windows of opportunity for technological transformation.** Such windows arise when contextual factors align with technological opportunity and are moments at which human agency can be exercised.

5) **The barriers and enablers to significant transformation need to be understood at both micro and macro levels.** Individuals can only act appropriately when there is an opportunity in their actual environment.

Adapted from original research proposal

The challenge is not the technical feasibility of a low carbon economy but making it happen.
Committee on Climate Change

In this project we have asked the broad question, 'How do we address the crisis of sustainability in all its manifestations?' and more specifically, 'What is it that helps and hinders the adoption of low carbon technologies?' These questions clearly have scientific and technical dimensions and scientific and technical research will remain important. But they are also questions about human skills and motivations, cultures and organisations. They are about how we see and define the issues – as problems, opportunities or something else – and about how we mobilise information, energy and resources to address them. They are about how power, politics and vested interests impact our knowledge and professional and social practice. Overall they are about how we transform our societies: the issues reach across nations, affecting ecosystems and societies in complex ways, and will do so far into the future.

Sustainable development is a truly multi-disciplinary endeavour, involving natural scientists and technologists, social scientists, business people, activists, economists, policy-makers, and ordinary citizens. Members of these groups have very different perspectives and interests: they understand their worlds in very different ways. The problems faced are very complex and there is no single framework for understanding which informs research. Researchers are working in a situation where even the leading thinkers do not agree about what we are trying to achieve, and where there are good reasons why it might not be possible to agree on many issues yet. This raises questions as to how research and development

What we need are teams of scientists who can predict climate change… engineers and technologists to come forward with solutions, and we need to work with international lawyers, social and economic scientists, even with historians to map out a future world which is a safer place for our grandchildren.
Sir David King, BBC Radio 4 Today programme, April 27 2009

projects can be defined and how communication between very different groups can be facilitated.

It can be very difficult to have meaningful dialogue about what is needed. Consultation and participative processes can lack depth and risk being trivial as people back off from the scale of challenge posed by climate change. Action research theories and practices therefore have a particular contribution to make in supporting people to understand and develop their different responses to the environmental crisis, and to work together toward a low carbon economy.

Discourses matter

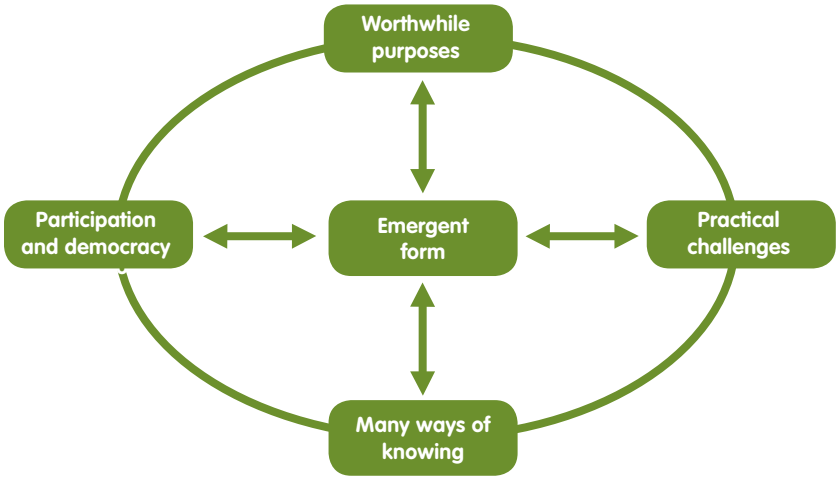
We explore the importance of different ways of understanding low carbon issues in **Theoretical reflections**.

In the rest of this section we provide an account of action research and narrative.

Action research

What is action research?

Action research is not simply a methodology. It is an orientation toward research and practice in which engagement, curiosity and questioning are brought to bear on significant issues in the service of a better world. Action research strives to create a close link between knowledge and practice. It sees research and inquiry as too important to be left to academics studying from a distance, and offers ways for people in organisations to inquire into their own practice, learn from experience and make sense of their actions. The role of the academic is to facilitate the learning and reflection process, and to find ways of engaging wider communities of practice so the learning can be passed on. There are five dimensions to action research, as the figure below shows.



Five dimensions of action research

> Action research is a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes… It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and, more generally, the flourishing of individual persons and their communities.
> **Reason & Bradbury, 2001**

Addressing practical challenges

Action researchers adopt a reflective and inquiring attitude to complex and messy human challenges, asking the question, 'How can we…?' We bring research into everyday experience and practice, creating a form of knowing which in turn informs experience and practice. This makes action research complementary to, but very different from, traditional scientific research, which is more concerned with 'pure' knowledge and control and rigour. Action research is about working toward practical outcomes and creating new forms of understanding, since action without reflection and understanding is blind, just as theory without action is meaningless.

> We cannot regard truth as a goal of inquiry. The purpose of inquiry is to achieve agreement among human beings about what to do, to bring consensus on the end to be achieved and the means to be used to achieve those ends. Inquiry that does not achieve co-ordination of behaviour is not inquiry but simply wordplay.
> **Rorty, 1999**

Worthwhile purposes

In this project, our starting point was the practical issue of how to increase the adoption of low carbon technologies. Our purpose was to improve the understanding and actions of those involved in this area, and our own, to further the shift to a low carbon world. Action research projects are unashamedly value-laden, asking what is most likely to help us build a freer, better society and contribute to the flourishing of human communities and the ecologies of which they are a part. Of course, what is deemed 'worthwhile' must always be addressed as part of the inquiry process.

> … most of our knowledge, and all our primary knowledge, arises as an aspect of activities that have practical, not theoretical objectives; and it is this knowledge… to which all reflective theory must refer.
> **Macmurray, 1957**

> I do not separate my scientific inquiry from my life. For me it is really a quest for life, to understand life and to create what I call living knowledge – knowledge which is valid for the people with whom I work and for myself.
> **Marja-Liisa Swantz**

The aim of participatory action research is to change practices, social structures, and social media which maintain irrationality, injustice, and unsatisfying forms of existence.
Robin McTaggart

We believe in participation, placing a strong value on democracy and control over one's own life situations. These values permeate our arguments and create a strong general commitment to democratising the knowledge generation process. Action research (AR) involves trained social researchers who serve as facilitators and teachers of members of local communities or organisations. Because these people together establish the action research agenda, generate the knowledge necessary to transform the situation, and put the results to work, AR is a participatory process in which everyone takes some responsibility.
Greenwood & Levin, 2007

Participation and democracy

Action research is founded in a belief that humans can work and learn creatively together, and creates new spaces for mutual exploration. It is participative, aiming to engage those involved in the action as co-researchers and equal partners, rather than research subjects. In this project, action researchers went into organisations engaged in low carbon change and worked closely with those involved. We also created special events, workshops and conferences, to deepen the inquiry process and explore findings more widely.

If you want to understand people's practice, you cannot do it from a distance. Primary evidence is gained only from active engagement with practitioners as they go about their business. As you engage and begin to think together, you begin to learn together. You may learn simply to do things better; but very often your learning transforms how you see the whole situation. You also learn how to learn, and develop genuinely innovative communities of practice.

Another reason for participative research is that it supports people who thought they were powerless to find they have power to do things. Action research is more than problem solving, it is at its best an educational and liberating process. And from a human rights perspective, we believe people have a right to be involved in creating knowledge, particularly about what concerns them. When it comes to tackling climate change, for example, this involves and affects every person on the planet, as well as the other species that live here with us. We cannot ethically leave the issue to the politicians and scientists.

Many ways of knowing

Western science has developed a very powerful form of inquiry based on rational (often mathematical) thought and empirical evidence. Yet we increasingly see the error of basing our theories on the myth of the rational economic man, as classical economics does. In focussing on the rational, we tend to ignore a wide range of other ways of knowing which include the experiential and intuitive, the aesthetic and presentational, the intersubjective and relational.

Of course these are open to all the errors and distortions to which human beings are apt. But as we all use these ways of knowing to guide our everyday actions, action research encourages individual and collective cycles of inquiry and reflection to check out what's going on systematically in practice, and increase their validity. In this project, we worked at each site over a period of time, using several visits to gather information and to work with participants to deepen our understanding. We engaged with participants' accounts of their experience, their particular ways of making sense of things, and experiments in action.

Emergent form

Action research projects bring discipline and system to people's natural learning processes. But because it works with the messiness of everyday life, projects cannot be predefined in any detail. Our world doesn't stand still as we engage with it, so projects emerge over time as those involved learn more about the issues to hand, try out new ways of doing things, develop relationships, and gain confidence in their exploration. In the language of complexity theory, action research is 'path dependent': what happens at any point depends in part on the choices that were made earlier. Which means it is really important for those involved to make choices as clearly and explicitly as possible.

Core disciplines of action research

Action research isn't a methodology. There are methodologies within action research, and we have used some of these in this project. But action research is an attitude towards inquiry and towards managing human affairs. Action researchers believe that research is about living life as an ongoing process of inquiry, so we are continually asking if what we are doing is worthwhile and whether our actions are truly effective in addressing our purposes.

The core inquiry disciplines are designed to offer rigour in projects addressing social as well as technical or scientific issues. They include:

Opening opportunities for dialogue

The first step in action research is to create opportunities for new kinds of dialogue where issues that are unrecognised, or actively suppressed, can be recognised, explored and taken into account. This 'opening of communicative space' allows diverse voices to be heard and contribute.

Cycles of action and reflection

The core process of action research involves iteration between reflecting and planning, experimenting with new and different forms of action, noticing what happens, and reflecting again. Action research projects are often structured to encourage this cyclical process.

Congruence

Are we doing what we say we are doing and is it having the effect we think it is? Cycles of action and reflection without a critical perspective may mean just doing the same thing again and again. So action researchers often look for match or congruence between what is claimed and what actually happens, because we often find that people's espoused theories (what they say they do) are very different from their 'theories in use' (what they actually do).

Reframing

This kind of critical cycling often means that people begin to see the issues in quite different ways. Their mental maps change; sometimes what they think is important changes, and so what they do changes. We know for example that people who get deeply involved in environmental issues (including government ministers) begin to see their world in very new ways.

Seeking ways of acting

It is very difficult to find a way of acting effectively in the face of an overwhelming issue like climate change. What we call 'inner and outer arcs of attention' can help participants to become more aware of their own internal processes (such as their emotions) as well as their action, and how these may be affecting their own perceptions. This makes it easier to set aside fixed assumptions. This process of exploration can help participants develop skills and structures which can help them recognise the complexity of the issues and still devise pragmatic responses to them, and to enter into creative dialogue with other people.

Dialogue and participation skills

As they participate in the research process, people from different backgrounds need to come together to 'think together', to bring their different perspectives to bear on complex issues. This is a skill that can be learned, and we can see that action research projects move from tentative beginnings towards full collaboration as participants develop relationships and learn the skills of working together.

Design and facilitation skills

This process is greatly helped by the introduction of structures and processes that facilitate conversation and collaboration. This calls on a particular facilitative skill which is at the heart of action research process.

Many ways of knowing

Experiential knowing arises in our everyday lived experience, through our encounter with our 'lifeworld'. It is the foundation of all knowing yet in many ways tacit and inaccessible to direct conscious awareness.

Presentational knowing grows out of experiential knowing, and provides the first form of expression through story, drawing, sculpture, movement, dance, drawing on aesthetic imagery. '…we come to experience the 'real world' in a manner that fits the stories we tell about it' (Bruner, 2002). This means that a powerful way of creating change is to portray things in new ways and find ways to tell new kinds of stories.

Propositional knowing draws on concepts and ideas and is the link between action research and scholarship. Theory can be a way of breaking with the common sense thinking that prevails in everyday life. The ability to develop alterative theories critical of everyday common sense grows out of in-depth examination of experience and new narratives.

Practical knowing, knowing-in-action, is what action researchers are looking for. Practical knowing is grounded in experience and narrative, is informed by theory and critical thinking, and is expressed through and in what we do. At the heart of practical knowing is an awareness of the quality of the practice in the moment. This is a form of embodied knowing beyond language and conceptual formulation.

Heron, 1996; Heron & Reason, 2001

Action research involves intent; a sense of purpose. This may be held tacitly. There may be multiple intents, in accord or discord. Often intents unfold, shift, clarify or become more complex.

Marshall, 2001

Validity processes

Because action research relies on the everyday knowing of human beings it is open to all the errors that humans are capable of. Action research brings a variety of validity processes which can uncover and undermine distortions in perception, group-think, and unwitting and inappropriate use of power in the inquiry process.

Significance of narrative

Through this project we have learned that story and narrative are important aspects both of action research and of low carbon change. Emphasising stories (rather than case studies) does not exclude theory and ideas, but rather provides a context for learning. Theories show the relationship between abstract ideas, while the distilled lessons commonly found in best-practice case studies are often de-contextualised and rather dry. On the other hand, a narrative retains the character, detail and drama that engages us on the level of human experience. Stories can show the way different issues come together to form a particular unique situation. They show us how events are unfolding and how those engaged are doing their best with what they understand and can do at the time. They show the messiness of the situation and the inevitable inadequacy of understanding.

Narratives serve not only to engage the audience but to help that audience to connect their own experience to the narrative and so learn on their own terms. They also stimulate a personal response from the reader/listener, highlighting the unspoken experience of people working in sometimes trying circumstances. American psychologist Jerome Bruner pointed out that we are psychologically programmed from an early age to engage with story, whereas the analytical mode of thinking common to organisational life is developed much later. However stories that include the ups-and-down of people's experience are commonly relegated to gossip in our modern-day organisations. Some researchers call this absence of 'official' stories a form of 'mythic deprivation'.

So using narrative is a way of retaining a liveliness and relevance to research. But further than this, we believe it will help the research travel. Philosophers of science have argued that scientific ideas are remembered not so much because they are true but because they are interesting – interesting in that they engage the attention and challenge experience (Davis, 1971). Action research can be very good at engaging the attention of the immediate participants in a project, but one of the challenges it faces is to spread this immediacy of relevance to a wider audience. In contrast to much social science which aims at 'repeatability' and 'generalisable findings' which, we contend, are often over-abstract and difficult to apply in practice, we are combining theories with narrative to stimulate a wider application.

Part of what we want to do in this project is to contribute to a change in the nature of the conversations about climate change and low carbon technologies – to change the discourse, in social science terms. Our research shows that successful low carbon projects are complex, multidisciplinary affairs involving many views and perspectives. We want the common discourse on low carbon to widen, so these views and perspectives are more naturally taken into consideration. We want to show how low carbon projects depend on the fine details of human endeavour which make the difference between something being taken up or being prematurely dropped. Our experience is that narrative accounts – good stories – do this well and are an important addition to the theorising which is common in social science research.

> Stories are:
>
> 1. The primary way we make sense of our experience, giving meaning and significance to our lives and creating (and re-creating) our sense of self.
> 2. A vital means of building relationships, bringing groups and communities together (discounting others' stories can cause conflict and divisions).
> 3. A powerful force in the world, acting on our imaginations to shape, constrain and free our sense of what is desirable and possible.
>
> **Mead, 2009**

> Most large organisations are 'mythically' deprived. Official documents and presentations are bereft of stories; managers talk in terms of highly rationalised, abstract explanations that do not typically tell how their numbers of policies really evolved…
> **Roth and Kleiner, 1998**

> A good story and a well-formed argument are different natural kinds. Both can be used as a means for convincing another, yet what they convince of is fundamentally different: arguments convince one of their truth, stories of their lifelikeness.
> **Bruner, 1988**

Learning histories

Our original plan was to find ways to identify situations in which organisations were working in collaboration with academic experts in low carbon technology. We wanted to support these collaborations, and widen their focus, by drawing on action research processes as discussed above. In some projects we were able to do this, engaging in more or less explicit cycles of inquiry with organisation members. However, we also found that much fruitful work could be done retrospectively by helping organisations' members reflect together and identify the learning that could be gleaned from projects already underway or more or less completed. So in addition to working in real time where we could, we adopted the learning history approach. We chose the narrative form to retain and share some of the living, experiential qualities of what actually happened.

> The goal of a learning history is to capture what an innovating group learned and can transfer from their 'new knowledge' to other groups and organisations.
> **Roth & Bradbury, 2008**

A learning history is described as a 'jointly told tale' (Van Maanen, 1998) between outsider researchers and insider protagonists. It starts with a tangible happening or outcome. It is a process that seeks to bring together analysis and story in a way that has value for those originally involved in the work, as well as those seeking to learn from it.

A learning history is an account that attempts to get into the individual human story of what happened, to get into the 'thinking, experimentation and arguments of those who have encountered the situation' (Roth & Kleiner, 1998). It aims to present perspectives on a situation rather than synthesising several accounts into one dominant researched 'truth'. It is presented as a multi-voiced and multi-levelled account so that alongside the narrative that charts what happened quotes are included from those involved, together with researcher reflections, questions and thematic analysis.

The first audience for our learning histories were those directly involved in the research. Through reflecting on and recounting their experiences with a researcher, and having the story played back with the voices of others, participants have an opportunity to take time out from fast-paced organisational life. Narratives based on learning histories, as in this document, are also valuable to a wider group of people who face a different set of similar challenges elsewhere.

We developed learning histories in a number of ways, typically by engaging intensively with organisation members both in their everyday meetings and through more formal interviews. We gathered evidence of learning and checked what we had heard with participants to ensure accuracy. We then worked with the material, crafting an account which used the many voices of those involved to present the story back to organisation members so they could engage with it together and draw from it the learning that was most important for them. We worked with organisational members to explore and articulate the key learning points, and from these experiences developed the narratives that are presented here.

One group of learning histories with six local authorities generated a second cycle of inquiry via a collaborative conference at which interested stakeholders explored the learning histories and discussed together the wider implications for that sector. This report is prepared as part of the preparation for a second conference at which we will explore our experiences with a wider audience.

Insider voices: Narratives from the field

As you get more and more projects and initiatives covered off you're thinking, 'This does actually make good business sense.' When you reach the point where people do it because 'it's the right thing to do,' not just because you're telling them they have to – you're really most of the way there.
Ginsters team

In this section we present narratives from six action research engagements. Further accounts can be found on the Lowcarbonworks website at www.lowcarbonworks.org.uk

Ginsters tells how a food manufacturing company moved from compliance with environmental legislation to investing in state of the art waste to energy technology.

Holsworthy anaerobic digestion is about a pioneering biogas initiative in a UK farming community.

CompAir Airworx explores the challenges facing a compressed air equipment manufacturer attempting to establish a compressed air service business.

Air Cycle tracks the story of a 'niche' technology, as a small group try to exploit a low carbon heating and cooling technology for applications in the food industry.

Thurulie eco-factory tells how a Sri Lankan apparel manufacturer commissioned and built an iconic low carbon factory to produce lingerie for Marks and Spencer.

Southampton District Energy Scheme is the story of collaboration between diverse stakeholders to build and operate a district energy scheme drawing on geothermal energy.

These narratives cover a wide range of low carbon technology applications in very different situations. Some draw on established technologies while others attempt novel applications; some are private sector and some public sector; some are quite local while others involved international supply chains; some are intentional, planned developments while in others change emerges over time. Many of the narratives are 'jointly told tales', developed in close participation with local actors, in which case we acknowledge the contribution of our organisational colleagues.

In addition to the core narrative, in each account you will find quotes from actors and public documents, researcher reflections, and links to relevant theories and tools. These are placed in boxes, each in a distinctive colour (please fold out the back flap for the key).

Ginsters

Building green credentials step by step: Changing perceptions of waste in the UK food industry

A jointly told tale written by Michelle Williams with Mark Bartlett, Larry File, Ray Hanly, Mac Hemmings and David Ion

This is the story of how a small group of committed individuals succeeded in driving forward the environmental agenda at the Ginsters food company in Cornwall. Through a combination of their relational skills and pragmatic business approach, the Ginsters team successfully implemented a series of small environmental projects with excellent pay-backs. On the back of their success they earned sufficient credibility to take an environmental leadership role within their Group and they are now on the verge of piloting a new waste to energy technology within the UK.

Cornish through and through

Ginsters was originally created in the mid-60s by Geoffrey Ginster, and started off with 22 people in a small hut in Callington, Cornwall, producing hand-made Cornish pasties. The company was bought by Samworth Brothers Ltd in 1977, and now produces three to 3.5 million pies, pasties and sandwiches per week.

Ginsters shares the site with its sister companies, Tamar Foods and Samworth Brothers Distribution. Ginsters focus on their branded products, whilst Tamar Foods produce exclusively for the supermarkets. Together, these three companies are now the largest private employer in Cornwall, with nearly 1000 people on site, 40% of whom live within one mile of the factory.

Ginsters are keenly aware of their importance as a local employer and are actively involved in a number of community projects. They recognise their responsibility to local farmers and have recently relaunched the Ginsters brand to emphasise their Cornish roots and local sourcing policy.

> We quite like things that illustrate that we think differently as a brand compared to the big corporate giants like Coca Cola.… We're Cornish, we're a bit different, we're helping the local community, and we're helping the environment.
> **Ginsters team**

> Early in the research I recognised the inherent paradox in discussing carbon reductions with a company whose product range is based primarily on red meat. Red meat consumption is growing fast around the world and is increasingly recognised as a major contributor to CO_2 emissions. From a systems perspective, I had to decide the boundaries of this research. I have chosen not to address these wider systemic issues with Ginsters, because I still have doubts about what is 'sayable' and what is still not sayable within the discourse around carbon reduction in the food industry.

First steps to sustainability

Samworth Brothers produced their first environmental policy back in 1997. According to the management team it was put together because 'everyone else seemed to have one' and it just represented some of the common sense things that the company was doing at the time.

> It probably represented at that stage a lot of nice words….it probably stood for the next five years as the 'Do you have anything on the environment? Oh yeah we have a booklet,' and would be produced at regular intervals.
> **Ginsters team**

Organisational responsiveness

This is an interesting example of a company progressing through increasingly complex levels of response to the climate change agenda. At the beginning of the story we see Ginsters at Response level one: Non-responsive, effectively ignoring the issue up to the point where industry pressure starts to mount, and they are forced to start taking some action.

Ginsters original factory in 1977.

It was not until 2002 that Ginsters took their first steps towards assessing their environmental impacts. They become aware of the new Integrated Pollution Prevention and Control (IPPC) legislation that would shortly be introduced into the food industry. The primary purpose of this legislation was for companies to gather data on their atmospheric emissions, set up a monitoring process, and produce a plan to reduce these in the future.

The task of preparing for the IPPC licence was given to David Ion, Head of Technical Services, but David felt he lacked the skills and time to do it himself, so he recruited Mark Bartlett to work for him. Mark was a qualified Environmental Health Officer, who was working in the factory at the time.

Organisational responsiveness

At this point in the story we see how environmental legislation is starting to act as the catalyst for moving Ginsters from a Response level one: Non-responsive company to a Response level two: Compliant one. They recognise the need to comply, but they do not fully appreciate the issues, and are not willing to commit significant resources to the project at this stage.

Before Mark was appointed to his role, Ginsters had relied on the services of an external environmental consultant, Mac Hemmings, for all their waste management work. In 1999 Mac was asked to look at options for dealing with Ginsters' solid food waste. As a result, he got involved in conversations with the newly formed Holsworthy Biogas company, who were planning to build an anaerobic digestor just down the road. The timing was fortuitous for both companies, as Mac had been investigating anaerobic digestion since 1996 and was able to help Holsworthy Biogas with some of their technical issues. The cost of Ginsters' waste disposal contract had been steadily rising so, when Ginsters decided to start sending their food waste to Holsworthy in May 2003, it was clearly a win-win situation for both companies.

Ginsters' suppliers

So I went to a meeting with these farmers and their Danish consultant in Bude… Basically my objective was to try and find out what these guys were going to do… they were going to use this new 'wonder process' of anaerobic digestion, which the Danes had developed for producing methane.
Mac Hemmings

Evolutionary economics

This part of the story demonstrates the notion of path dependency. Ginsters were looking for new ways to dispose of their waste, and Mac Hemmings had already spent a number of years investigating anaerobic digestion in the background. So Ginsters were primed and ready to get on board with this new technology when it appeared. Another company, without this previous history, might have chosen differently.

Building the team

When Mark Bartlett picked up his new role he immediately struck up a good relationship with Mac Hemmings, and the Ginsters' environmental team was born. Meanwhile, an informal coalition was forming between David Ions (Mark's boss), Ray Hanly (Operations Director) and Mark himself. Although they were working at three different levels in the organisation, they developed a mutually supportive relationship, with the common aim of furthering the environmental agenda at Ginsters.

So you can say some of it happened subconsciously by coming together and discussing about what we were going to do, and it just became part of the day job, if that makes sense?
Ginsters team

Diverse coalition and Daring not to know

The coalition that formed between these three managers cut across the organisational hierarchy. There was a strong sense of trust, respect and mutual support for each other. None considered themselves experts in the field, but they were willing to learn from each other and from outside experts, as they went along.

Mark and Mac's first task was to prepare for the IPPC licence, which had to be submitted in six months' time.

Learning to collaborate

When the IPPC legislation was first introduced into the food industry it only applied to large-scale food companies, producing in excess of 75 tonnes per week. Ginsters on their own would not have qualified, but because they shared a site with their sister company, Tamar Foods, the Environment Agency decided to treat them as one company. The effect of this decision was far-reaching. Samworth Brothers was structured so that each company in the group operated completely autonomously, under a federalistic approach. So the Environment Agency's decision forced the two companies to collaborate on a project for the very first time.

Mark Bartlett was charged with gathering environmental impact information from both companies. He was technically employed by Ginsters, and found he had a difficult job trying to overcome the suspicions of some of the people at Tamar Foods.

Now all of a sudden these guys have got to work together, because if one of them gets it wrong, the other gets it wrong by default. But at the application process this was completely new, you know, they couldn't work out why they were having to.
Ginsters team

Mark managed to get the information he needed and also helped to foster a closer working relationship between the two companies, which has persisted to this day. He is now responsible for the environmental management across both sites.

I think Mark Bartlett did a lot in his subtle approach about keeping chipping away at it. You could say if he wasn't resilient about it, wanting and passionately wanting to make it happen, he could have gone, 'Well sod you, I'll crack on with my own bit'. He knew not to do that and he kept his motivation going throughout.
Ginsters team

Enabling culture

This highlights the importance of investing time and energy in building trusting relationships. Without this groundwork, Mark may not have got the information he needed from Tamar Foods in order to perform his role effectively.

Dealing with the red tape

The task of pulling together the information for the IPPC licence proved much harder and more complicated than anyone had imagined.

No one seemed to realise just how involved this thing was going to be, and everyone seemed to think that Mac and I would, sort of, squirrel ourselves away in a room for an afternoon and, you know, knock up the application…
Mark Bartlett

The legislation was new to everyone – Ginsters, the food industry and even the Environment Agency. Mark and Mac had a steep learning curve to climb and a short time in which to do it (they were given six months by the Environment Agency).

The Environment Agency had issued a CD with an electronic version of the IPPC application on it, which Mark thought would make their life easier. But Mark and Mac went through six different versions before they could get it to work properly.

So I spent most of my time on the phone to their IT support telling them 'yeah it's gone, it's wiped everything again' and they were going 'Could you possibly compile a list of all the problems you found, and send them to us…' We were bug testing their damn application!
Mark Bartlett

Another issue was the lack of capacity within the emerging environmental testing industry. The Environment Agency insisted that all emissions testing work had to be done by companies who were accredited to a body known as MCERTS.

It was a case of trying to find a company that did it… At the time there was one company in the UK, and as you could imagine with the IPPC, they were rather busy…
Mac Hemmings

Having struggled with all these challenges, Mark and Mac finally submitted the application in January 2003, on the day of the deadline. Even that was not straightforward.

It was about twelve different duplicates we had to produce I think. We managed to kill one photocopier, and we went through God knows how much ink. But we started about eight o'clock in the morning and finished about one in the morning…
Mark Bartlett

When I heard Mac and Mark tell their story I didn't know whether to laugh or cry. It was a classic story of two lonely champions battling it out against the odds, and finally winning the day against an unsupportive system. It made me appreciate the sense of passion and commitment that environmental champions need to have in order to achieve change.

Relational practice

Mark's relational skills played a key part in furthering the environmental agenda at Ginsters. His ability to communicate across different departments, to gain their trust and support, enabled him to take effective action. At the time it seems as though this relational work was not fully recognised or appreciated. But, through the process of constructing this learning history, Mark's two line managers were able to reflect back on the value of his relational work and 'reappear' important aspects of his practice.

Overcoming obstacles

Looking back at the application process, Mark and Mac both reflected on how much confusion there was within the industry about the Government's handling of waste. This served to make their jobs much harder.

There was confusion over what constitutes 'waste'.

> We have waste from here but as soon as it goes through the gates at Holsworthy, technically it is a raw material… And if you ask the [Environment] Agency when is a waste a waste, it throws them into total confusion and chaos, more than normal, because they can't answer it logically.
> **Mac Hemmings**

There was confusion between government departments over roles and responsibilities with regards to environmental policy-making and enforcement. This made it hard for Mac and Mark to know who to speak to when they had a problem.

> Now you've got the situation where you've got the Environment Agency and Defra working essentially for the same ministry of people, the veterinary side are all in the same ministry, and they both hate each others guts, and so they don't talk to each other. And these are the people enforcing the legislation, and then depending on who you go to is the answer you're going to get.
> **Mac Hemmings**

The consequence of all these political obstacles, according to the Ginsters team, is that there are far fewer companies operating green technologies like anaerobic digestion than there should be.

Power and discourse

This is an example of how different social groups find it hard to talk to each other, even with a supposedly common agenda. In this example, the various waste and energy departments within the government were struggling to communicate, making it virtually impossible for the business community to know how to engage with them. The consequence of this was to make the business community feel angry and powerless at their inability to get on with the task they had been given.

> You've got to be seriously committed to doing it to go up against all this red tape, you know… I'd be amazed if there aren't quite a few people who have gone into this with the best of intentions and just given up.
> **Mark Bartlett**

Generating small wins

At the same time as Mark and Mac were going through the IPPC process, they were also trying to improve the effluent treatment plant at Ginsters. They were concentrating on liquid waste only, having found a suitable solution for their solid waste problem through Holsworthy Biogas.

The waste management function was largely invisible to the company before Mark took it over.

The opportunity for Mark and Mac to raise the profile of waste treatment, and to get some money to upgrade the facility, came by chance. Tamar Foods picked up some additional business from a local company, to make desserts for the supermarkets. This resulted in a huge increase in the amount of sugary liquid waste feeding into the effluent plant. The consequence of not processing this liquid waste properly was potentially catastrophic, in the sense that Ginsters could have been shut down by the Environment Agency for breach of consent. Mark was able to persuade the Board to invest in a new bio-filter in order to cope. The bio-filter cost £120k, but paid for itself in less than six months.

Waste disposal facilities, effluent treatment plants, are not the sexy, glamorous side of the business. They are a necessary evil, they are an overhead, they are a cost, they don't make anything, but they have to be there. The level of investment in the original effluent plant? It was very clear that it was at the bottom of the agenda!
Ginsters team

The success of the new bio-filter paved the way for a number of other investments in the effluent plant. There then followed another small win for the environmental team as a result of the emissions testing work they had done for the IPPC licence, which highlighted a fault in one of their ovens.

Before IPPC there was no requirement for us to emissions test on site at all… the only work that was done was basic boiler and oven burner efficiency… We made annual savings getting that burner fixed somewhere in the region of about £8,000 to £10,000 a year.
Mark Bartlett

As you get more and more projects and initiatives covered off you're thinking – 'this does actually make good business sense.' When you reach the point where people do it because 'it's the right thing to do,' not just because you're telling them they have to – you're really most of the way there.
Ginsters team

Organisational responsiveness

We can see here how a number of seemingly small projects are contributing towards a 'tipping point' for Ginsters. The company are starting to put environmental procedures and measuring systems in place which will move them from a Response level two: Compliant organisation to Reponse level three: Efficient management. This is the point where legislative compliance starts to align with corporate cost-saving objectives, and environmental concern makes good business sense. The Ginsters' Board are becoming more supportive, but there is still more work to be done to embed sustainability into the corporate strategy.

Maintaining the momentum

Following the impressive pay-back of the effluent treatment projects and the repairs to the gas burner, the internal momentum to improve resource efficiency continued to build. Ray, David and Mark seized this moment to create the company's first Energy Management Team.

Part of the 'seizing the day' bit is to recognise that when a potential change is taking place, that's the key moment to make sure that the environmental challenge is put forward. …the key element of that is having somebody who sits there at the meeting and says 'What about the environment?' It's as simple as that really.
Ginsters team

Systemic understanding and timeliness

Individually and collectively this three man team were able to spot an opportunity in which to exercise their agency. They were able to pick up on the signals, and take a strategic decision about when to get the environment on the corporate agenda.

This part of the story emphasises how laying the groundwork for environmental change can be a long, slow and dull process. One key to success for the Ginsters team was their ability to wait patiently until the right time to make their move.

They recognised that one of the key organisational changes that had resulted from the IPPC application process was a movement towards a more collaborative style of working. They wanted to build on this momentum, so they invited the heads of engineering, operations, technical and finance to join a cross-functional team. They also encouraged bottom-up participation by adding the environment to the agenda of their existing Health and Safety committees, and invited factory staff to nominate themselves as environmental reps. They developed a system of rewards to encourage the generation of ideas, and they added the question 'What have you done for the environment this year?' to every staff review.

We've got notice boards throughout the place, we've got suggestion schemes, and so on…. If people put forward ideas and they do work, then we make sure that they get the credit.
Ginsters team

Amplifying feedback

The systems that the team put in place to reward ideas and actions helped create a supportive environment for innovation. People put themselves forward as environmental reps because of the high profile of this agenda and apparent organisational support for it. They wanted to be part of the emerging corporate story around 'the environmental team'.

Through the newly formed Energy Management Team they started investigating their use of water, followed by electricity. With help from the Carbon Trust, they improved their efficiency in both areas and generated some significant cost savings. This in turn encouraged the Board to incorporate environmental issues into the Corporate Strategic Plan. 'Environment' became one of the six 'strategic pillars' of the organisation, and a cross-functional working group was formed to focus on the delivery of the corporate environmental strategy.

It's that sort of stepping stone approach… in talking about the overall story that we have, it's the recognition that you don't step from being one colour to green the next, it's actually a progressive transition. And as I say, learning the language is an important element of the process.
Ginsters team

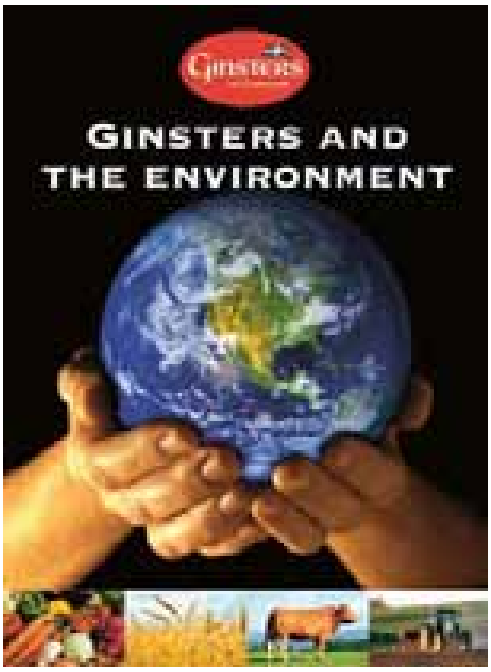
Organisational responsiveness

At this stage we can see Ginsters fully established at Response level three: Efficient management. The environmental agenda within the company is being talked about differently. It is no longer just about cost cutting, it is now seen as an integral part of the business strategy. Through the team's efforts there is now much greater awareness of sustainability throughout all levels of the company.

Enabling culture

The organisational culture at Ginsters played a significant role in fostering the proactive approach by the team. The company is still privately owned, and both Ray and David had developed a good personal relationship with the two Samworth brothers. They commented on how this made them feel trusted by the Holding Board, who were willing to give them the space and time to experiment.

Several people mentioned that there is no 'blame culture' within Ginsters, but rather an emphasis on being proactive and pushing the boat out as far as you dare. This was similar to the 'can-do' approach fostered by the management team at MAS Intimates. Perhaps this is a reflection of the fact that both companies are still privately owned and family-run?



Sharing the learning

As a result of their pioneering approach, Mark, David and Ray have become acknowledged leaders in environmental management within Samworth Brothers. They are keen to share the lessons they have learnt, and have begun to roll-out a set of environmental policies and practices throughout the Group.

It's almost a case of there being an internal knowledge transfer network… Because we're all part of the same group – you can be much more frank and open and honest then you would if you were dealing with a potential competitor.
Ginsters team

The team are facing a new set of political challenges as a result of assuming this leadership role within the Group.

[Here] it's easy because I sit on the Board so I can influence my colleagues… When you go into another business there can be a little bit of resistance … We needed to be very subtle in how we did it.
Ginsters team

Relational practice

The team learnt a lot about the political culture at Samworth Brothers through their experience of trying to implement the IPPC. They understood which relational practices were likely to work and which were not. Reflecting on this experience helped them to make strategic choices about how best to build internal support for this new initiative.

Moving ahead of the curve

Mark, David and Ray continue to push forward the environmental agenda at Ginsters and, at the end of 2008, the Samworth Brothers Board agreed to fund an exciting new investment into a state of the art waste to energy technology. This new technology will allow Ginsters to process all their waste (both wrapped and unwrapped) on site and use a bio-mass incineration process to generate energy and hot water to power their bakeries. This will potentially be the largest investment of its kind by a private company in the UK.

This makes us self sufficient. It's a total waste management system, on site, run by us. We're not making a profit, we run it at cost. It puts us, well, basically, in control. It makes things like waste disposal costs over the next five to ten years a known quantity.
Ginsters team

As much as we like to drive innovation, there's a lot of people in the group who are very nervous about this. The first stage is we get this in, we prove this and again it comes back to tracking down the pay-back. Once they're happy with that, fortunately, because a lot of this kit is modular, you can just bolt stuff onto the end of it.
Ginsters team

The team are keenly aware of the risk they are taking and have consulted widely with various technology providers to ensure they have sufficient information. They are looking for a technology which will give them enough flexibility to cope with an uncertain waste and renewable energy market in the future.

Agency and Enabling culture

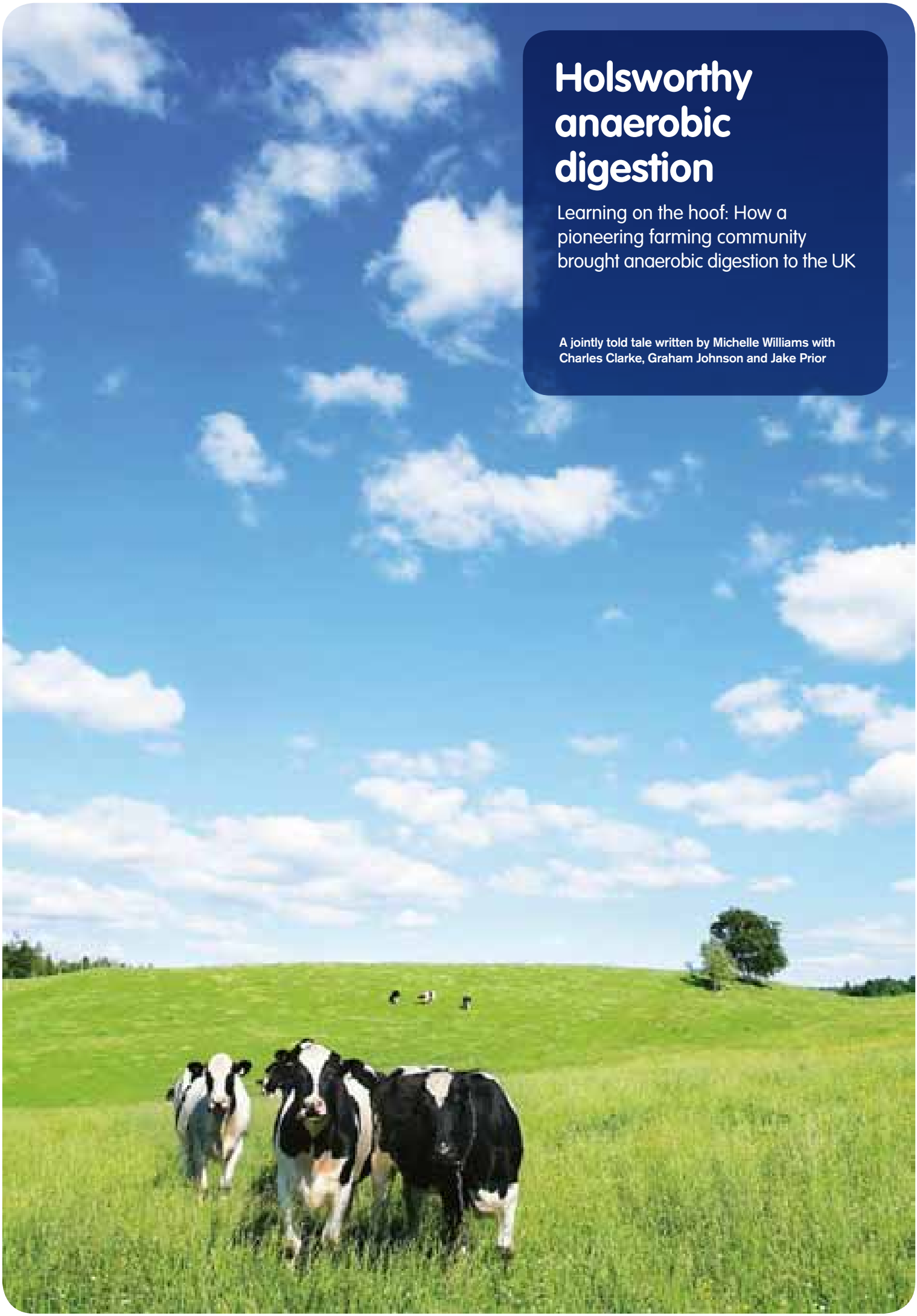
The team are willing to be proactive and experiment with this emerging technology because of the support they give each other, and the enabling culture in which they are operating. They feel personally supported by the Board of Directors, who are willing to underwrite the experiment and accept the risk.

I'd rather be making change from the inside for the long term benefit than trying to be the irritant on the outside that people can just dismiss – you'll be dismissed and you'll become a peripheral player. And you might still add value to the business in other areas, but in actual fact you won't have forwarded the environmental agenda within the business at all.
Ginsters team

Organisational responsiveness

The Ginsters Board is actively supporting this search for a new low carbon technology, which suggests that the company is now moving into Response level four: Breakthrough projects. They have recognised the multiple benefits that a project of this kind could offer in terms of financial benefits, future security over energy supply and waste disposal, and enhancing their reputation with their stakeholders (especially the food retailers).

Despite the obvious progress that Ginsters have made in terms of their response to climate change, I was surprised that there was no actual reference to 'carbon reduction' during any of my conversations with the team. Energy efficiency and waste reduction were clearly seen as the right things to do, but they were not explicitly linked to a carbon reduction strategy. I wondered how a successful outcome for the waste to energy project might help to move them further along this path.



Holsworthy anaerobic digestion

Learning on the hoof: How a pioneering farming community brought anaerobic digestion to the UK

A jointly told tale written by Michelle Williams with Charles Clarke, Graham Johnson and Jake Prior

This is the story of a pioneering group of farmers and businessmen in North Devon, who built the first large-scale anaerobic digestion plant in the UK. It is a heroic story of grand ambitions, of crossing boundaries, of building coalitions and of 'learning as you go'. It is also a story of perseverance and struggle. Struggle against a regulatory system where this new technology was not fully understood or appreciated. Struggle to transfer the design and technical knowledge from a continental European context into a UK one, and struggle against a vocal minority of local residents who continue to oppose the plant. This is not a classic success story, but rather a story about what it takes to keep going against a backdrop of constant change and uncertainty.

An exciting idea

The story of the Holsworthy Biogas plant begins in 1993/94 when an enterprising group of local business people from North Devon and Cornwall formed the North Tamar Business Network (NTBN). They had access to EU funding (provided under the EU 'LEADER' community development programme) to pump-prime local projects. The Executive Leader of the group was Joe Talbot, and Charles Clarke was a well-known local farmer and founding member. It was Joe Talbot who first introduced the idea of an agricultural project, based around the production of biogas from farmyard slurry, having heard about the process at a recent conference.

> The Executive, Joe Talbot, came up with four categories of project: agriculture, education, tourism and business. My hat could have gone on any one of those four at that particular time, but I went with agriculture. And one of the things that Joe Talbot mentioned was biogas. Well, having an inquiring mind I said, 'What's biogas?'
> **Charles Clarke**

Wide vision

Both Joe Talbot and Charles Clarke were acting in a strategic capacity here, with an eye on the bigger picture. Joe Talbot was able to spot a timely opportunity, and Charles Clarke was willing to keep an open mind and to explore how this opportunity might fit within the NTBN's wider plans.

The biogas idea took hold, and in 1996 the network decided to conduct a feasibility study. They had high hopes that this new technology, called anaerobic digestion (AD), could provide a way forward for local farmers suffering from falling incomes and the effects of the BSE livestock epidemic at the time.

> Holsworthy is predominantly a farming community and in common with most rural areas it has suffered in recent years from the effects of the agricultural recession, in particular the BSE crisis. The local economy is dependent on milk production, cattle rearing and tourism… The fragility of the rural economy and the opportunity that the biogas plant offered to stabilise the economy was one of the key factors behind the development of the project.
> **'Energy Management' Feb 2000**

Holsworthy town centre.

Sociotechnical transition framework

The momentum for this project did not come out of nowhere. It emerged out of a context of growing economic instability in the farming regime which could be linked to wider systemic issues around farming practice in the UK at the time. This instability may have provided the impetus for the farmers in Devon to be actively looking for ways to diversify, thus providing a 'window of opportunity' for a niche waste to energy technology such as AD to break through.

Forming coalitions

With the help of the technical expert that Joe Talbot had first heard talking at the conference (Dr Clare Luckhurst) the group started looking around for information on AD and soon realised that there was little to be had in the UK. Most of the existing UK plants were operating in the waste water industry, with none in the food and agricultural sector. By contrast, this technology was firmly established in Europe, and had been operating in Denmark and Sweden for nearly a decade.

Holsworthy leads the UK in state-of-the-art green energy

Holsworthy moved a little closer this week to being the first town in the UK to seize for itself the opportunities presented by the Green Energy Revolution. All European member states are committed to increasing the amount of energy obtained from renewable sources, but the proposed Biogas Plant at Holsworthy would be a first for the UK… Other European countries, notably Denmark, have perfected the technology necessary to operate a centralised biogas plant. There are currently 18 Biogas Plants up and running in Denmark and the Holsworthy plant will build upon this experience and expertise.

North Tamar Business Network 'Local Information Sheet' 1999

With no real knowledge of this technology, and in the absence of a learning community in the UK, the NTBN decided to employ a Danish Consultancy, Bioplan, and a specialist district heating consultancy, Mertz Orchard, to help them progress. They visited a number of biogas plants in Denmark to see the technology in operation. Bioplan were subsequently replaced by another Danish consultancy, NIRAS, who took over the design and development of the plant.

External networking

In the absence of an established knowledge base in the U.K., the project leaders consciously built a wider network from within Europe.

We learnt about biogas on the hoof. We went to an awful lot of people.

Charles Clarke

Daring to not know

The leaders of this group were not technical experts, so they set up a Steering Group to provide a forum within which the NTBN and their European partners could learn together.

Over the next few years, there followed a number of Steering Group meetings between the NTBN and their two appointed consultants. As the minutes from these meetings show, there were clearly contextual difference in the practices and policies surrounding farming in Denmark, compared to the UK. Thus, in some important respects, the configuration of the technology for the Danish market did not necessarily meet the needs of the farmers in Holsworthy. Some of these differences included the fact that manure in the UK is generally wetter than in Denmark (which makes it more difficult to process) because the animals are kept outside, and it rains more! There is also less fear amongst Danish farmers about contracting diseases such as TB (through spreading the end product, known as 'digestate' on their land) because TB was completely eradicated in Denmark in 1952. AD operators in Denmark are further protected from this risk by getting their customers to sign a contract to exclude them from any blame for the spread of any infectious diseases. For UK purposes, the project group had to commission some costly research to determine how long the farmyard manure should spend in the digestor, and at what temperature, in order to guarantee that all the pathogens would be killed. Without this guarantee the farmers may not have been willing to take the digestate.

He [the Danish consultant, Lars] admitted that TB is not a problem in Denmark, and therefore has not been researched that extensively… Lars advised that in Denmark a clause is included in the supply contract that prevents a farmer from blaming the Biogas Plant for the spread of any disease. Lars continued that in Denmark the Biogas Plants were actually seen as a positive means whereby the risk of spreading certain notifiable diseases was contained…

Minutes of Holsworthy Biogas/ Consultants meeting 1/3/99

Reading this excerpt from the minutes, I found it hard to imagine UK farmers signing a disclaimer like the one used in Denmark. This made me wonder whether the Danish farming community has more understanding, and therefore less suspicions, about new low carbon technologies like AD, or whether the Danish government has put legislation in place to provide a more protective environment for the technology providers?

One of the most important differences between the Danish design and the needs of the UK market was to do with odour control. The potential for bad odours to emanate from the plant was not considered high priority by the Danish designers because, apparently, the Danish public were less concerned about this particular issue.

The Danish Biogas Plants viewed by the project team do not automatically include Odour Control systems, since the smell the plants can produce is not seen as that significant.
From a progress report by the NTBN to MAFF 29/3/99

Aerial view of plant from www.andigestion.co.uk.

As the story progresses it becomes clear how a seemingly small cultural difference like this can fundamentally affect the potential for a technology to be successfully transferred from one context to another, and how close attention needs to be paid to such differences right at the early design stages.

From its initial conception in 1996, it took over six years to design and build the plant, which meant it did not officially open until July 2002. The design phase of the project took much longer than anyone expected, and some of the delay could be attributed to the redesign necessary to deal with these UK-specific issues.

Social shaping of technology

This part of the story supports the proposition that technological innovation is not a linear process, moving neatly from invention to innovation and diffusion. In this narrative, the final design configuration was socially shaped to meet the specific needs of the UK market, following a lengthy negotiation and development process between the technology providers, designers, plant operators and potential customers.

Complementaries matrix

One of the issues of this story is the mismatch between the intentions of the farmers and the opportunities in the wider environment. This is discussed further in the tools section.

Raising the money

By 1999 the NTBN had agreed that Charles Clarke would take over the management of the project, working with the European advisors, because the network felt it lacked the capacity and the time to progress it properly.

Charles Clarke was the real driver. Without his persistence we wouldn't have learnt anything.
Graham Johnson, Plant Manager

Agency and Translator go-between

Charles Clarke was willing and able to assume leadership of the project when the circumstances required it. His relational skills enabled him to operate across a range of different expert-knowledge constituencies (i.e. chairing the meetings between the technology providers, designers, local authority and local farmers) and he possessed the communication skills necessary to translate between them.

So Charles and three colleagues set up Holsworthy Biogas as a 'special purpose company' in 1999 and became co-directors. With the help of the NTBN and Torridge District Council, they managed to secure a grant of £3.5m from MAFF (Ministry for agriculture, fisheries and food, later replaced by Defra). This was the largest EU and MAFF grant in the West Country at the time. The balance (up to a total of £7.7m) was to be raised by private investors and commercial banks. The Directors put in some private money of their own, but they needed to find a project partner to fund the rest. So they issued a European tender, visited two potential technology providers in Germany, and selected a company called Farmatic to design, build and finance the project. At that point they decided to terminate their contract with the Danish consultants, and to rely completely on the expertise of Farmatic.

From Andigestion brochure (formerly Holsworthy Biogas).

This decision to move away from the Danish Consultants and to co-finance the project through Farmatic seems to be a pivotal moment in the story. Several of the project participants expressed disappointment that there was not enough risk capital for investing in green technologies in the UK at the time. They were forced into a co-dependency relationship with an overseas company that they knew little about, and with very little time to establish a trusting relationship.

Building local partnerships

After Farmatic came onboard, Charles Clarke and his team turned their attention to building local partnerships. The project had first started to gain momentum when the local district and county councils had realised how it could help them achieve their sustainability objectives, and had joined as project partners on the MAFF funding bid. This was now becoming a true community project, with strong public-private sector partnerships starting to form.

It is intended that development of the Biogas Plant will put Holsworthy on the renewable energy map and make the town a place of pilgrimage for those interested in Green Energy.
North Tamar Business Network 'Local Information Sheet' 1999

At the beginning of the design process, some of the aims of the plant were far-reaching and ambitious, even by today's standards. One such aim was to use the CHP (Combined Heat and Power) unit to provide renewable electricity and to generate hot water to run a district heating scheme.

The CHP plant will provide a source of hot water for a district heating main. Initially this will supply the community buildings in the town (hospital, schools, sports hall, memorial hall and council offices) but with the ring main established it is anticipated that private householders will also want to join the scheme and benefit from this source of low cost heating.
North Tamar Business Network 'Local Information Sheet' 1999

To help them realise this aim, they needed to sell the scheme to as many local public sector organisations as they could, and they employed a specialist district heating consultancy, Merz Orchard, to help them do this. Merz had a rather disappointing response from the local schools and hospitals, but a much more encouraging response from the local council. The council were about to refurbish their offices in the town centre, and wanted to avoid any further disruption later on, so they put in a connecting pipe between their offices and the plant before the plant was even finished. Unfortunately, the district heating scheme never happened, but the council's pipe is still there today as a testament to the high ideals of this pioneering group.

I think events really overtook us… because of the design problems that we had we couldn't guarantee the hot water, and secondly, the price of piping etc. just went through the roof and it became something that couldn't happen…
Charles Clarke

I noticed how most of my interviewees spontaneously mentioned the district heating scheme, and how disappointed they had been that it never materialised. I sensed that the community service aspects of this project were a significant driver for them, and had helped to keep their motivation going throughout the early days.

At the same time as Merz Orchard were busy trying to drum up support for the project amongst local public sector bodies, the Holsworthy Directors were working hard to get both local food producers and the local farming community on-board. As part of this strategy, they personally visited every single farm in the area during the period 1999/2000. This personalised approach proved to be highly effective, because by the time the plant opened, in July 2002, 30 farmers had become stakeholders in the company. The idea was that once the loans were repaid the farmers would share in the profits, and a community trust would be set up to aid local economic development.

There was a whole group of us. Other farmers etc. who were interested in it. The NFU were very supportive. I knew a lot of farmers and through the NFU Secretary we contacted ones that were likely to be interested. It was basically the dairy farmer side of it.
Charles Clarke

The directors were also very active in approaching local food companies, because they had been advised by their original Danish consultants to aim for a mix of 60% farmyard manure (a low energy feedstock) with 40% food waste (a higher energy feedstock) in order to maximise the amount of biogas that could be produced.

Ginsters were one of the first food companies that Holsworthy Biogas contacted, right at the beginning of the project in 1996, in order to establish their level of interest. They had a significant amount of food waste each week (mainly pasty returns and out of date packaged food) which was proving difficult and costly to dispose of. Whilst Ginsters had expressed interest in the project all the way along, they were not legally permitted to send their food waste there until a change happened in the law in May 2003 (ie. 10 months after the plant eventually opened). Ginsters saw the move to Holsworthy as a strategic approach to reducing their business risk, and a cost effective alternative to their current arrangements. Without a secure disposal route for their food waste they could risk being shut down by the Environment Agency.

It was one of those crazy things with the animal by-products regulations, [which] came into effect in May 2003. Before this piece of legislation it was illegal, for some reason (it was down to the planning or something)… for us to send our food waste to Holsworthy. And then, from 1st May 2003 it pretty much became the only legal option!
Ginsters team

Relational practice

Anaerobic digestion is a technology which requires considerable relationship building across a number of diverse stakeholders in order to make it work. The leaders of the Holsworthy group had strong social ties in the area through their experience as local farmers and businessmen. They possessed a high degree of tacit knowledge about how best to communicate with these local groups in order to gain their trust and support. They were using strong relational skills to build the networks and coalitions that they needed to operate the plant successfully.

From Andigestion brochure (formerly Holsworthy Biogas).

Falling out with the neighbours

Through the hard work that the project team put in to building local partnerships, and the sheer determination to overcome the technical obstacles, the plant did eventually open in 2002. But not everybody in Holsworthy was happy about that. One of the original claims of the project, written in a local information sheet, was that; 'Anaerobic digestion reduces the odour from farm slurries and food residues by up to 80%'. It was on this basis that the project team consulted with local residents and neighbourhood groups at the start of the project. But, owing to the more relaxed approach to odour-control in Denmark, the project team had needed to develop a whole new odour-control system just for the UK. When Farmatic took over the design of the plant, they tried to make this system as 'green' as possible, by using biological filters. But when the plant opened, the size of the plant, and the odorous nature of some of the food waste they were taking (especially blood) meant it proved ineffective.

This was not the only technical issue surrounding the plant after it opened. There were also problems with the reception pit, and the mixing tanks, which meant the plant often had to be stopped to rectify various processing problems.

The odour issue, together with complaints about the noise and the increase in lorry traffic, resulted in a vitriolic campaign by a small group of local residents calling themselves the 'Holsworthy Biogas Protest Group'.

The protest group has now officially disbanded, but postings on their website at the time suggested they felt the plant had not fulfilled its original community aims and objectives.

Graham Johnson, the company's chief engineer… blamed the plant's German builders for 'bodging a membrane on a slurry tank.' He admitted: 'We have had bad odours. Not so much in the past year but in the summer of 2003 it was bad. There are houses four or five hundred yards away and it was not pleasant for them and it was unpleasant for us at the plant as well.

'Bottom Falls out of dung power market' *The Times* 7/2/2005

Power and critical thinking

It could be argued that the local residents were exercising their power in the only way they could after the plant had opened. By not consulting them more extensively during the design process, the project team may have effectively excluded their voices, thus exercising a form of 'Non-decision-making power'. This could have generated the feelings of anger and frustration which led some of them to form this local resistance group.

We had no choice but to go into administration. More money was needed to build new tanks and contain the smells, and negotiations with the bank broke down. The plant was something we believed in and we thought we could make it work. My family and I put in £25,000 which, with the benefit of hindsight, wasn't the best move in the world. But the Holsworthy plant is still a going concern, and I hope it will eventually work.
Bryan Lewens, Chief Executive of Holsworthy Biogas in 'Bottom Falls out of dung power market', *The Times* 7/2/2005

Reaching the end of the road

The ongoing problems with odour, on top of all the other technical issues, proved to be the final nail in the coffin for Holsworthy Biogas. Despite achieving a turnover of over £1.3m in 2004, the plant still needed £250k to build a second slurry tank and install more odour-resistant glass fibre roofs. Cash flow became an issue, and Ginsters stepped in to provide some emergency funding and the services of their Operations Director on the Board.

But, in March 2004, Farmatic went bust. Soon after that, the German bank called in their £2.8m loan. After an adventure lasting nearly 10 years the directors of Holsworthy Biogas were finally forced to sell.

There were clearly technical issues which led to the demise of the plant, but there were also relational issues between the German contractors and the Holsworthy project team, which made it hard for them to work together. For example, one of the Holsworthy team described how cultural differences, compounded by a lack of time, made it hard to build a trusting relationship with Farmatic. Another described how Farmatic may have 'over-stretched themselves' by trying to build four plants in Germany at the same time as Holsworthy. Whatever the real reasons, it is clear that there is a more complex explanation for the demise of Holsworthy than a simple failure of the technology to work.

A fresh start

In 2005 the plant was bought and rebranded Andigestion by Summerleaze Ltd., a renewable energy company, based in Maidenhead. Buying Holsworthy was a strategic move for them, allowing them to move further into the waste to energy sector. Jake Prior was a major shareholder in this family run company, and he moved to Devon and put his heart and soul into getting the plant to run more efficiently. By mid 2008 it was making a profit for the first time.

Jake invested a considerable amount of money replacing faulty equipment and dealing with the noise and smell issues. He also spent many long hours working at the plant, learning about this new technology.

It's been very, very challenging because the plant had so many problems… whether with the smell where we had people shouting at you, and the farmers were shouting at you… and things go wrong in a 24 hour seven days a week process. With one particular problem I could only fix it on a Sunday night. So I had to spend all Sunday night for several months, opening valves and pumping things around – so you wouldn't just do it for the money. The money hasn't even been that good yet! But it is just such a good process, you know? However long you do it, it's amazing how it all works.
Jake Prior, Summerleaze

He discovered that a myriad of skills are required to operate an AD plant successfully, including an understanding of the waste and energy markets, chemical and mechanical engineering skills, and an ability to market yourself to both waste suppliers and digestate customers. But Jake attributes much of his success to his understanding of how the UK electricity market works.

This place had a contract under the old electricity support mechanisms and non-fossil fuel obligation… We basically bought it on the assumption that we would be able to terminate this contract. Which isn't an easy thing to do – hardly anybody has terminated these contracts – and I think that put a lot of people off buying this place… but we'd done it before and thought we could do again. So having the knowledge about the electricity market and how to buy and sell electricity and what to expect with the prices gives us an advantage, I think.
Jake Prior

When I first met Jake I was impressed at the sheer enthusiasm that he had for the process. This was clearly a man who loved the technology. I sensed that the challenge of getting it to work properly was as much a motivation for him as making the plant profitable. I wonder if someone who was less of a technical 'enthusiast' would have shown the same level of commitment and determination.

Changing priorities

When Jake Prior took over the plant, and it became self-financing, a number of conditions that were attached to the original MAFF grant became obsolete. One of these conditions was: 'To contribute significantly to achieving Torridge District Council's and Devon County Council's Local Agenda 21 targets for Energy and Transport, Land, Air and Water Pollution.' In addition, there were conditions relating to education and knowledge transfer, such as producing a range of information packs for schools and businesses in the area, launching a website, and speaking at two national or international conferences.

The grant money was for experimentation and knowledge. It worked for this. We learnt a lot
Graham Johnson

Graham Johnson remembers having a constant stream of visitors every week when the plant was under community ownership. When the plant was sold and passed to private ownership there was no longer any obligation to conduct such educational work, and it is hard to tell how much of it continued.

According to Graham Johnson, the number of anaerobic digestion operators in Denmark is restricted by law, thus creating a kind of 'closed shop' and less intense competition amongst operators. Apparently, the Danish operators all get together at least once a year to discuss industry-wide issues. He believes 'that would never happen in the UK'. This makes me wonder about the role that good story-telling (i.e. by creating learning histories of this kind) can play in helping to stimulate and spread learning across a competitive industry.

Another change that occurred when Summerleaze bought the plant was a shift away from its original purpose as a community project, helping local farmers to manage their waste, to a renewable energy project, focused on generating biogas. In June 2008 Jake Prior took the decision to stop taking slurry from local farmers. His decision was based on the problems of processing the slurry (the straw often caused the equipment to clog up) and because he could generate more biogas from food waste, rather than farmyard waste. Despite allowing the farmers to keep their slurry storage tanks free of charge (originally paid for by the project) there continues to be some disappointment amongst the local farming community who have to find a new solution to their original waste disposal problem.

Jake Prior working at the plant.
From www.andigestion.co.uk

From Andigestion brochure (formerly Holsworthy Biogas).

I'm determined to show that AD actually works; both environmentally and economically. Having been involved with it since 2001 and seen the economic drivers changing slowly in its favour, to walk away now would seem to me to be a bit of a failure.
Graham Johnson

Looking to the future

Jake Prior has continued to develop the plant at Hosworthy and, together with other operators in the AD industry, he continues to lobby the government to improve the conditions in which they can operate. For example, there is now discussion about developing a new quality protocol for the digestate, to classify it as a fertilizer rather than a waste, which will make it easier to sell. The government has also doubled the financial subsidies available for the sale of the renewable electricity generated, by offering double ROCs (Renewable Obligation Certificates) to AD providers. Jake is now trying to set up a number of other AD plants around the country.

Tenacity

Jake showed considerable tenacity in overcoming the technical barriers which were stopping the plant from running efficiently. Beyond this, he was willing to challenge the rules and standards which he felt were constraining the industry overall, and preventing this technology from breaking in to the agricultural and renewable energy regimes.

Charles Clarke has retired from farming, but continues to play an active role in his local community in Holsworthy.

Graham Johnson, and a number of other Holsworthy employees, continued to work at the plant for some time after Summerleaze took it over, but he has since left and joined another waste management company in the local area. He remains disappointed that AD has been so slow to get adopted in the UK, but he has not given up his ambition of starting an AD plant in Cornwall in the near future.

I found this part of the story particularly poignant. Those lonely pioneers back in 1996, who took the risk and stepped out into the unknown, did not have the personal satisfaction of seeing this new technology more widely adopted in the UK. I hope that by telling their story this might help to give them some of the credit they deserve.

CompAir Airworx

The fourth utility? Transforming compressed air supply from product to service

Written by Chris Seeley and Carole Bond with thanks to Vernon Edwards and Graham Pearl

This story seeks to make sense of a truncated, unsuccessful change process which, if a different pathway could have been found, could have led to widespread reductions in carbon emissions in the supply of compressed air. It is a story of good intentions and being caught in the wider systemic web of UK industry conventions. Airworx is a service offering compressed air as a utility from CompAir, a long established manufacturer of air compressors.

In UK manufacturing, the norm is that compressed air is supplied from compressors situated near to the point of use, with the required capital equipment being owned and maintained by the manufacturer using it. This can result in inefficient equipment being used which is technologically superceded (especially in energy efficiency terms), poorly maintained and simply worn out.

We sell very efficient equipment that people wrongly apply and energy efficiency therefore goes down.
Sales Director

Elsewhere, for example in parts of France, the norm is different, with compressed air being supplied as a utility to manufacturers, just as electricity and gas are. The capital equipment in this case is not owned by those who use the compressed air, but by the utility supplier. As with the photocopier industry, such a product to service shift ensures greater efficiency through the regular maintenance and upgrading of the capital equipment needed for the job.

Sociotechnical transition framework

CompAir were caught up in the web of the prevailing sociotechnical regime in the UK, which did not see compressed air as a utility and valued capital equipment over service agreements as they would appear on company balance sheets as part of the company's asset base. Airworx was seeking alone to make a change at the sociotechnical regime level, not in conjunction with other industry sector players. Such a systemic intervention, carried out on a lone basis was not strong enough to destabilise the existing regime. Had CompAir been in a position to seek and create a coalition of relevant industry players, Airworx might have been a more resilient proposition at this time. We would suggest that, unless the Airworx service offer could be framed explicitly at the level of a response to climate disruption and CO_2 issues then energy efficiency and cost savings alone would not have offered sufficient traction for such a sector-level coalition to have formed. In addition, we suggest, at a policy level, that such sector level coalitions need support and encouragement in their formation, facilitation and maintenance.

Airworx offers a massive saving, but it just won't move forwards. The saving could be £100k. I want to ask the customer: 'What part of £100k saving don't you understand?'

Through their Airworx division, international compressor manufacturers CompAir, sought to offer such a 'utility air' proposition through a product to service shift.

What is Airworx?

AirWorx has been developed as a service package based on CompAir skills, technology and hardware. AirWorx enables major users of compressed air to save money, meet energy reduction targets, reduce capital investment in plant and maybe most importantly stop worrying about compressed air. You simply purchase the compressed air you need from CompAir.

Generally 30% of the compressed air generated is wasted. The energy saving potential is significant as industry is currently using 8-10% of its electricity consumption for compressing air.

Compressed air is generally treated as a support function. Depending on the application the quality and availability of the compressed air may have a significant effect on the plant's core production. However, as a support activity it seldom warrants the attention it really deserves leading to operating costs much higher than necessary.

From the users point of view, compressed air is only another utility comparable to electricity, water or gas. These other utilities are however mostly generated off site and simply supplied to the end user as required. The nature of compressed air does not allow for it to be transported for distances and therefore most users historically own and run their own compressed air systems.

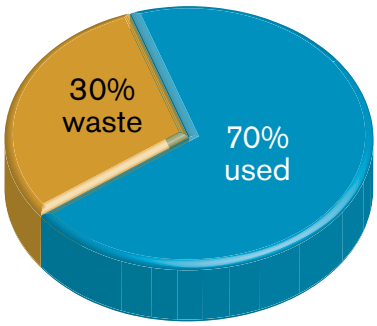
With this in mind CompAir has developed an innovative program for outsourcing of your compressed air that we call AirWorx. In most circumstances there are significant operational cost savings that can be realised with an AirWorx supply agreement.

CompAir is well aware of the fact that the AirWorx approach is very much a partnership agreement. For this to be successful, it must benefit both parties. This benefit comes from the improvement in system performance and from allowing both parties to focus on their core businesses. We do not have one model that will be applied to all AirWorx contracts. Instead we are prepared to work together with you to find the solution that best fits your needs by using a modular approach.

An essential part of creating a solution is to assess the starting point and the requirements. Compressed air systems often develop over decades and the applications and performance can be very individual. Compressed air users also do not generally have a very accurate understanding of the system or compressed air related costs, due to the usually low priority of compressed air.

In order to allow both parties to understand the present performance of the supply side as well as the distribution network, we strongly suggest that system measurements are performed. This is an important part of the AirWorx approach and we call it an AirWorx AirAudit.

By signing up for an AirAudit, your company does not commit to anything further, other than working together towards an optimum AirWorx proposal.
CompAir website



In CompAir's offer, they would effectively sell compressed air as a kind of local utility to individual manufacturers' sites, retaining control over and ownership of their own equipment situated in the factory and negotiating five to seven year service agreements.

Such agreements were set to offer significant cost, energy (and CO_2) savings for participating manufacturers, and yet the offer has not been successful in the UK.

According to Airworx' Sales Director in November 2005: 'Uptake of this product offering is patchy. There has been low uptake in the UK (five or six contracts only) compared with 100 contracts in France and 50 in the rest of the world'.

The rise and fall of Airworx

2.1 Hopes to increase sales

The Lowcarbonworks research team was welcomed into the CompAir/Airworx sales process in late 2005 by its Sales Director as a means to:

…see an increase in the uptake of service based contracts as opposed to corporate purchase based supply.

Environmental issues, under the guise of 'energy efficiency' were initially recognised at Director level as being a driver for this work:

We're taking the moral highground.

There is a need for a standard for compressed air.

With this mandate to go into CompAir, we met with the whole of the relevant sales team as part of their regular team meetings on February 2006. The team quickly showed great trust and openness to us as a research team. The work was starting to feel more like consultancy than research as we listened to the team members' stories of their struggles to sell the Airworx service. We asked the team: what might you be wanting from this project?

- Orders
- Understand at what point of the sales process does it need to change to make it a more successful outcome, or, at what point does the client say 'this isn't for me'?
- Getting feedback from the customer side
- Finding out more about what our customers want
- Looking at existing models that work (banks have been doing this for years)
- What is stopping the uptake of these particular technologies?

The UK is the market that has kept compressed air utility at bay.

Airworx just ain't working.

Airworx offers a massive saving, but it just won't move forwards.
Sales team meeting notes
23 February and 24 March 2006

Quite often, the guy that's buying isn't responsible for the energy costs. And the accountant (who doesn't understand the technical side) is in charge of the purse strings.

Environmental issues, let alone carbon reduction, were not on the agenda for the sales team and their potential buyers:

I am increasingly dropping 'environment' into conversations too to encourage uptake of these machines. However the CompAir distributors are not picking them up as they can't make as much money as from selling the oil based machines (generally, the more spillage, the more money they make).

People want to protect their own jobs and are fearful that Airworx type contracts will undermine their own position.
Sales team meeting notes
23 February and 24 March 2006

At this stage, as researchers we felt optimistic that the research would lead us to convening multi-stakeholder groups from the decision makers around Airworx services.

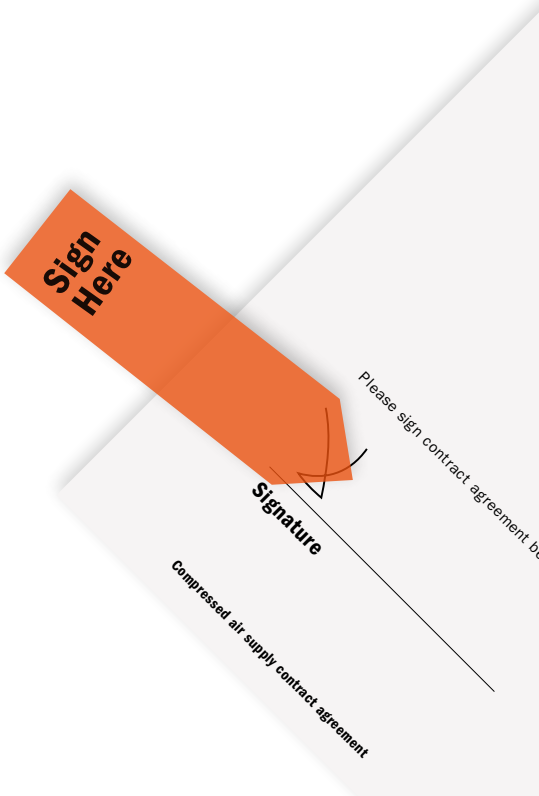
2.2 Selling Airworx contracts: a difficult context

Complementaries matrix

We took a 'plain English' version of the complementarities matrix as a framing to inform and guide our discussions with CompAir's Industrial Sales Area Manager in March 2006. The wording we used at CompAir for the four quadrants was person / job / company / industry.

The UK is the market that has kept compressed air utility at bay. The UK has always been a traditional cap-ex market. It changed a little when British Steel first started to fail. It has stuttered and started around this for 15-20 years… British companies are permanently up for sale… so they want assets… The Airworx business model is from Australasia. People in the UK are fearful of it.
Airworx sales team

We discussed the complementarities matrix with Airworx' Industrial Sales Area Manager and this clarified the picture of the complex and blocking context in which he was working. Notice how many of the comments are inherently negative and, as such, contribute to a sense of being locked-in to the current 'sociotechnical regime'.



Person

Personal beliefs, eg: 'Even if I do something it won't make a difference'

- Engineering Manager can see Airworx service as a threat (diminished empire)
- People reluctant to accept that they can save money without spending anything
- Fear of change
- Job changes
- Complicated sales process- fear of misunderstanding/looking ignorant
- Can't read man's expression
- Who he plays golf with/existing relationships.

Job

Structural, practical issues at work, eg: 'Not enough experience of speaking in groups'

- For engineering management equipment costs are not part of their budget spend. With outsourcing the capital ex is factored into the unit price which then makes it too expensive
- The sales process can take up to two years
- A lot of people think they understand what utility air is, but actually what they want is a glorified service contract
- Lack of awareness about outsourcing
- Wrong person is tasked with the job
- Custom and practice.

Company

Company beliefs, eg: 'Sharing knowledge weakens our position'

- Facilities management is more common in the UK
- Capital plant costs are visible on balance sheet
- Running costs often not known, makes sales case more difficult to prove
- Life costing is not part of the business
- The sign off for Airworx is at Board Level
- Lack of confidence on business (fear of long contracts)
- Company goes up for sale during sales process
- AirWorx Distributors have wrong business models
- Airworx is acting like a bank to customers
- Energy and environment are new disciplines
- Company recruitment/understanding of/systems for energy and environment.

Industry

Structural cultural issues, eg: 'UK tax on biofuel'

- New industrial estates don't put in reticulation systems
- Cultural issues – the French have used air as a utility for years
- Eligibility for Government's Capital Loan scheme.
- UK is traditional cap-ex market (companies are always up for sale)
- Custom and practice.

Complementarities matrix

Using the complementarities matrix to analyse Airworx' situation, we can see that instead of the '*potentially virtuous circle*' of interrelationship between the different quadrants, we have a situation where the pressures and norms in different quadrants are working against one another. For example, that these types of industrial companies (including Airworx itself) are perpetually up for sale means that they want to keep hold of their equipment as a saleable asset, and that the contract takes a such a long time to arrange means that one or other of the parties may have moved on, or had their company sold in the intervening period.

The contract values are very high – up to £2.5 million and the sales rep could be in line for 0.5 – 1% of this in bonus. However the negotiations for outsourcing contracts are highly complex:

- They are multilevel sells working with decision making units (DMUs) within the target company, who are taken through a series of workshops to help gain buy in from the engineering management to help influence the Finance or Managing Director.
- They involve precise calculations; the word 'estimate' is never used in a proposal, it is based on actuals.
- All this means it can take a year or more to progress.

The contract negotiations are therefore handled not only by the sales rep but also by both the Sales Manager and the Sales Director.

> In one sense they are selling but in another they are really putting together a collaborative partnership… so there was this complex relationship with the different organisations involved that would get right to the brink of closing a deal and then the deal wouldn't be closed because there were so many changes going on.'

Sociotechnical transition framework

In CompAir's case, the technological niche is represented by the product to service shift to 'utility air', provided by the CompAir brand Airworx, working as a contractor outside of the manufacturing company concerned. This work was seen as fringe within CompAir and was further marginalised to the extent of being stopped entirely apart from residual contracts.

The sales team and consultants were locked tightly into meeting their immediate objectives as defined by the sociotechnical regime. This seemed reasonable given the context of the fragile short-termism of the UK manufacturing industry, but meant that, at these levels in the decision-making process, players were effectively unable to see and act from bigger, systemic views. How, then, might people in sales roles become better equipped to convene groups of decision-makers to have open and strategic, not just tactical, defended, discussions?

One of the Airworx sales team said: '[Buyers] are blinkered – "we've been doing it this way for years."'
Meeting notes, 23 February 2006

> There were all sorts of things going on about technology and about people's ability to understand the technologies involved and about people's belief systems around who was telling the truth about them. Then each side would bring in their own experts and those experts would disagree with one another… and hiring experts and specialists in. The whole thing just got more and more convoluted and complex… it was a hall of mirrors.

From the buyer perspective, this narrow focus on keeping the sociotechnical regime locked-in to 'how things have always been' was partly held in place through widely publicised Government loans for energy-efficient capital purchases.

Companies that are eligible for the UK Government's loan scheme for energy efficient products were generally not targets for the CompAir outsourcing offering.

Indeed, the very provision of such loans, designed to encourage the uptake of energy efficient equipment, fundamentally fails to take account of the whole life use of that equipment and the consequent energy efficiency losses incurred through poor installation and maintenance regimes.

There is talk of an eco-labelling scheme for air compressors. The EU will impose this if the industry does nothing voluntarily. Eco-labels on the equipment are not the issue. It is rather the quality of the installation that dictates the energy efficiency overall.
Meeting notes 20 November 2006

The information gathered during our meetings and particularly through the use of the complementarities matrix populated and enriched our picture of the sociotechnical regime for compressed air in the UK (albeit from the perspective of people working in CompAir at that time). The perception of the sociotechnical regime we developed as researchers is, then, systemically bound, contextually-specific and time-specific.

Sociotechnical transition framework

We suggest from our research that the implementation of consistent, purposeful strategic intent at CompAir based on understanding and acting on the broader sociotechnical landscape was weak, and readily undermined by the multiply-locked-in and fearful nature of the underlying sociotechnical regimes. This left the Airworx offer unprotected, vulnerable and not nurtured as a technological niche. In addition, the communication of these issues from a policy perspective to the industry as a whole was nowhere to be seen in our discussions (at least not in this country… there are examples of top down pressure from utilities in California).

Geels and Schot (erroneously, we believe) claim that changes in the landscape occur slowly, quoting 'factors that do not change or that change only slowly, such as climate' (Geels and Schot, 2007). Today, the awareness of rising CO_2 levels is changing rapidly whilst the effects of atmospheric CO_2 increases are both accelerating and becoming increasingly unpredictable (non-linear). Whereas in 2005, discussions around energy efficiency and mentions of CO_2 only really happened at Director level in our research with CompAir.

Carbon consumption is starting to come from the top down as opposed to dealing with energy costs at only an operational level.
CompAir Sales Director meeting notes: 20 November 2006

Perhaps the Airworx team were in too early, or perhaps they got out too soon, or perhaps they just didn't hang in there for long enough.

There seemed to be 'shear' points created by the varying paces of and between the different levels of change – some changes were operating relatively quickly and were ready to go (the idea of the product to service shift and the technologies

themselves), others took their own time (the two plus year sales process) and others still were dogged with locked-in inertia (the overall sociotechnical regime). At the landscape level, it seems to us that players did not see or expect rapid change in the sociotechnical landscape and that their actions lagged behind accelerating shifts in the widest context. Specifically, the sales team showed little or no knowledge of the environment/sustainability sociotechnical landscape and so they were not equipped to be leading a conversation around the issues with their clients or even to be building a robust business case around them.

2.3 Pathways to transformation blocked

The Airworx experience suggests that (enough) multiple conditions, moving at multiple paces, need to converge together in order to unlock a regime and open up a transition pathway through to a new (hopefully more sustainable) one. This implies an 'all at once' change phenomena of flowing in all directions at different paces rather than a linear process. This, in turn, suggests that tipping points need to be 'found' or unlocked rather than be incrementally worked towards.

CompAir Airworx suggests that a robust transition pathway has not (yet?) been found. The path to transformation was blocked at many junctures. The sales push of the technological niche of Airworx has been truncated because:

- the climate debate seems to be both lost and implicit in the discussions about utility air. Carbon was implicitly present, and stated to be so with some of CompAir's potential clients. Yet it was a long way off from the pragmatics of simply sorting the finances
- resistance to change and lock-in (both on the part of CompAir, its consultants and its buyers) to current sociotechnical regimes was strong
- little concern was paid by any stakeholders involved in the process to the broader sociotechnical landscape issues of carbon reduction
- no one sought to convene wider, systemically aware conversations (that otherwise would not have happened) amongst the different players in the decision-making stakeholder group
- even where there was awareness of the broader eco-sociotechnical landscape, sales people within a marginalised small department of a relatively small company did not find their agency beyond their immediate (time-consuming) job tasks.

This leads us to question: must pressure to change in the socio-economic landscape be screamingly obvious for players locked into the existing sociotechnical regime to notice?

Then, in 2006, the Sales Director informed us that the Airworx service was to be withdrawn, as the company itself was being prepared for sale amidst fears for job losses and short term thinking.

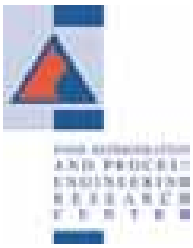
Organisational responsiveness

The significance of the capacity of this organisation to respond to this complex situation is explored in some detail in the **Tools** section.

Air Cycle integrated heating and cooling

The challenge of developing niche activities

A jointly told tale written by Gill Coleman and Michelle Williams with Judith Evans



The literature on 'sociotechnical' innovation suggests that new discoveries frequently find form in 'niches' – small pockets in which an interconnected network of people nurse a new technology through its teething problems, away from the full force of operational or market expectations. But little is explained about how such niches operate in practice, what challenges they face and what helps them work. This story tracks the experience of Judith Evans, a project manager, engineer and researcher at the Food Refrigeration and Process Engineering Research Centre (FRPERC), Bristol University, and the Air Cycle Link Project – a project supported by Defra to discover ways to exploit a low carbon cooling and heating technology, using air under pressure.

> I'm never sure whether you should take these things in just one direction or whether you should go in as many different directions as you can, with the idea that as long as you put enough effort behind it, one of them is going to be successful.
> **FRPERC Project manager**

Two of us from the LCW action research team started working with the project from their first meeting, and had an opportunity to talk to the main partners over the subsequent months and years.

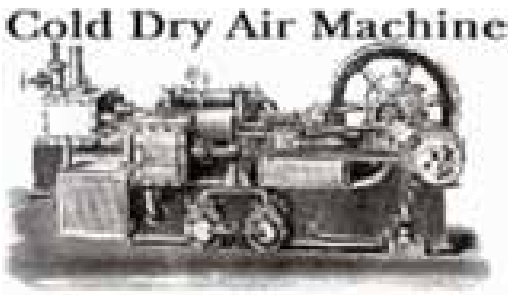
The background

Air Cycle systems use air under pressure to create heating and cooling. The technology was originally developed in the early 1900s for use on board ships and by food manufacturers and retailers. Poor efficiency and reliability in the early systems led to them being replaced by vapour-compression units, using refrigerants such as ammonia, and more recently, CFCs. But new developments in the manufacture of components have improved the performance of Air Cycle systems to such an extent that there is renewed interest in them. Air Cycle technology is currently used by aircraft manufacturers and a German train manufacturer for air conditioning.

A group of refrigeration researchers based at Bristol University's FRPERC have been pioneering the development and possible use of Air Cycle systems for commercial refrigeration in the food industry. The technology has the potential to provide rapid and integrated heating and cooling capacity suitable for cook-chill or cook-freeze processes, which is reliable, safe, efficient and more environmentally benign than current refrigerants.

In 2006, Judith Evans and her team applied to Defra for funding through the Advanced Food Manufacturing Link scheme, for a three-year project to develop and demonstrate the system's commercial potential to possible users and system suppliers. In particular the researchers were trying to exploit the fact that an Air Cycle system can cook food at high temperature and then chill or freeze it in one integrated and energy-efficient process.

The project brought together the FRPERC research/development team, manufacturers of parts used in Air Cycle systems, independent energy consultants, representatives of a food industry interest group and people (mainly technical directors) from food manufacturing companies. Under Link project rules, collaborating



Old Air Cycle machine. Credit: FRPERC

partners match product funding through contributions in cash or in kind, participate in the disseminating of results and have some access to intellectual property generated through the project before this is open to the market.

As we will see later, these rules were to prove problematic for the research team.

The main objectives were to

- identify the heating and cooling requirements of the industrial partners,
- identify food products or processes for the purposes of demonstration
- build a prototype, and transfer it to an industrial site to test it
- optimise it in the light of feedback

Link funding aims, therefore, to bring technologies out of their pre-commercial niche, in such a way that commercial users can identify sufficient measurable benefit to justify the further investment necessary to bring them to market. A number of energy saving refrigeration technologies are supported within the Link portfolio, in the hope that some will be successful.

All Link programmes seek to promote exploitation of public research innovation for the benefit of the industry, assuring deliverables that can make a difference and within a specified time frame. Projects aim to deliver high quality pre-commercial research with significant potential for commercial exploitation through a consortium structured to provide an eventual route to market and to ensure uptake and impact. The pre-commercial R&D needs to be sound, innovative and fit for purpose. Projects are likely to focus on areas of market failure and/or carry a level of risk such that industry is unlikely to fund the research without the support from the Link Scheme.

Defra Advanced Food Manufacturing Link

Convening partners

Before the project could begin, Judith found herself ringing around possible project partners, 'selling' the benefits of participating. Having worked in the refrigeration field for some time, she is well known in this professional community, and has run previous partnership projects. She found the industry people, in particular, challenging to get to the table, and had to use her powers of persuasion and the promise that this might be a way for them to offer cost-savings through reduced energy consumption to their companies. Several of them told us they participated on the basis of knowing and respecting her, rather than being drawn by the nature of the project or having much sense of what benefits it might bring them.

As a business, it's hard to know how to connect in to the research community, and find out where the 'centres of excellence' are. You read things and pick up snippets, but it's hard to tap into. Knowing FRPERC helps. It works for them as well, hard for researchers to find their way into businesses.

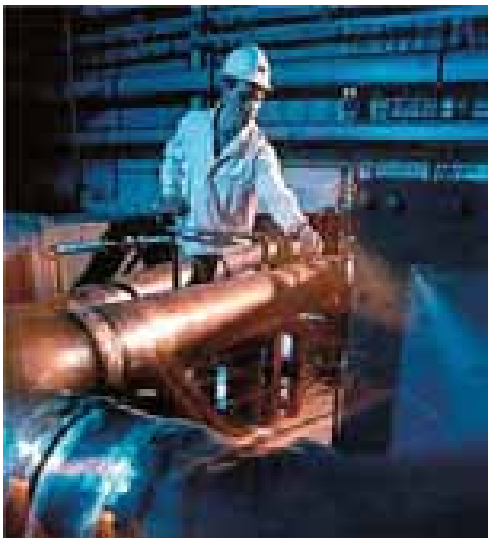
Food manufacturer

I think a lot of the partners were, 'the usual suspects' if you like, people who've had an interest in the past. I mean, we had a special interest group and some of the partners were on that. Some of them were involved in previous air cycle projects, so I think you tend to go for people you know who are going to be interested, or that's the theory, because if they're interested they'll put the contributions in and help you do the work.

FRPERC researcher

Relational practice

Judith had to work hard to get Link partners to the table: she managed it because she already had relationships with some of them – and they respected her – and she had to build them with others, and try and assure them that this would be time well spent for them. The time and effort she spent on this – it took her six months – is invisible: it is not noticed or acknowledged as part of the work of the project, and Judith herself did not see it as a particularly valuable element of her role as Project Manager, and struggled to fit it in alongside her normal work. Fletcher calls this a 'disappearing dynamic' – a widespread and routine failure in workplaces to value the work of building and maintaining relationships. As an engineer and academic, Judith did not notice the skills she was displaying: she said 'I have to be a bit of a salesman!'



Building Air Cycle rig. Credit: FRPERC

These kinds of informal networks seem to play an important part of how academics and researchers interact with both manufacturers and equipment users in the 'refrigeration community' – as in other interest groups. There seems to be a broadly shared sense of the contours of the community – who are its big players, where the sticking points are, what its opportunities are. We might say it has acquired a 'common sense', a way of thinking about refrigeration in its current technological and commercial context, which is reproduced through meetings, projects, conferences.

Evolutionary economics

In terms of evolutionary economics, this is a 'routine'.

The project was framed by the academic team. They set the tone, issued the invitations, initiated the language in which the project was conducted, set the agenda for meetings, wrote and distributed minutes and so on. At the outset the project coordinator, in her opening presentation, made a connection between the energy-reduction potential of the technology and the government's goal of carbon reduction in the light of climate change. But the subsequent presentations and discussion, stretching over the next few meetings, mainly involved explaining the technical features of the system, and the challenges to be faced in moving from theoretical modelling to practical demonstration, using component parts contributed by project partners.

Power and critical theory

The FRPERC team were exercising 'incumbent' or 'agenda setting' power here: although they were not very aware of doing so, they were controlling what was talked about and the manner in which the talking was done, so putting the visitors from the commercial sector at a disadvantage. It was very difficult to achieve collaboration in such circumstances.

We noticed that there was a certain lack of clarity from the start of the project about what might come from it. Although the technical benefits of Air Cycle include lower energy use than alternative refrigeration technologies, the FRPERC team were also interested in the fact that it could provide integrated heating and cooling, using the energy created by air under pressure. It is also capable of producing very low temperatures, which might be of interest to manufacturers who currently use liquid nitrogen. It needed an innovative response from a potential customer, who could help the team shape how this might work in practice. It could also provide a solution to the problem of leaking refrigerants, which is endemic in the food industry and a significant source of greenhouse gas emissions. But even at the invitation stage, Judith had had little option but to suggest to the companies she was talking to that Air Cycle might offer them cost savings, in order to attract them to participate. This in turn put the academic team under some pressure to show what they described as 'some good numbers' in practice.

Background to the food industry

Conversations with Peter Jarman, the Defra Project Monitoring Officer, provided background to the industry.

> What you have on the project is the highly-motivated end of the food industry. Not the run of the mill. They are the exception. For the normal people energy is way down, they just don't care.
> **Energy consultant**

> We have chilled factories, many built about 10 years ago, tall, shiny, cold factories. We cool the whole building, then spend money keeping people warm so they can work effectively – handling knives etc. We are wondering why we do it like that, and how we can manage temperature in a more efficient way, get cleverer about it. …There was a previous Link project on that. In the end it didn't go anywhere because the cost of changing the factories was so great. Those sorts of changes need an interface between plant and people.
> **Food manufacturer**

- Food is a 'non-growth industry'. The total volume of food is static – but there is a move towards added-value products. Industry competition, therefore, is intense.
- It is dominated by a few retailers, so that supplier margins are squeezed, and there is less money available for food innovation.
- It is not resistant to change, but innovation tends to be focused on products not process. Applying a product-focused mindset to process innovation leads to a demand for short-term payback from process equipment, lack of strategic and long term thinking
- Manufacturers don't buy new equipment unless they have to. They prefer to 'sweat the machinery' – running at over-capacity for as long as possible and avoiding disruptive change. Flexibility of equipment is vital – because product life-cycles so short.
- The industry is highly fragmented, which makes large scale adoption of new technologies or practices made more complicated.
- Highly innovative products are often not successful at first. Food companies are nervous of moving ahead of the market – they prefer to be 'fast-followers'. Sometimes new products/technologies are 'parked' and then launched into market when the timing is seen as more favourable or competitive.

> In any year, we might replace 30% of our product range, it can be very short term. So we don't do changes to bespoke equipment unless various steps have been gone through. We need flexibility in the processes to cope with the changing product range, and also degrees of confidence.
> **Food manufacturer**

> Most factories have just added and added incrementally for years. I have seen factories with ovens dating from the 1930's! They end up with plants much bigger than you need, which have to be heated and run, because they add things on, and it grows like Topsy. You need an airport runway to lay out all the kit you need to produce some of this food.
> **Energy consultant**

> [Food manufacturers] are not technical people and they don't quite understand it, and they don't want to show that they don't understand, and they don't want to tackle what the data might reveal – that one site might be much more efficient than another, or one process might. In some places, all the food is frozen twice! They will go to the ends of the earth to source something like tomato purée a few pence cheaper, but pay no attention to their energy costs.
> **Energy consultant**

> The people who develop products tend to be driven more by an exciting new idea… they're innovation driven because I guess they have a lot of added value on their products.
> **FRPERC researcher**

Air Cycle cooling-heating tunnels. Credit: FRPERC

We could see, then, that this was a difficult environment in which to innovate. Everything in this food sociotechnical system – the interaction of human processes and technology that gets food onto the retailers' shelves – is geared around short-term results. Consumers have learned to expect plentiful cheap food. The supermarkets which dominate the sector want swift and reliable delivery of a flexible range of standardised products at the lowest possible cost. Spending of all sorts amongst suppliers is squeezed. Capital expenditure needs to repay itself in months rather than years, and immediate, visible cost-savings or product innovation takes precedence over longer-term investment or adjustments to take account of contextual changes. This mind-set might well work against those hoping to introduce energy saving technologies, if the primary focus is on the long-term welfare of the planet rather than short-term economic paybacks.

Sociotechnical transition framework

We might see this as an example of a 'dynamically stable' sociotechnical regime. The food industry is 'locked-in' to technologies which are modular (i.e. capable of separating the cooking and cooling functions); capable of being 'bolted-on' to existing equipment; small in size and offering short pay-back periods, tightly linked into a centralised food distribution system, logistics systems, accounting systems, pay and reward systems, marketing and sales systems, retail practices consumer expectations and cultural habits concerning food. It is extremely difficult to unpick any single piece of this interconnected whole. Air Cycle does not fit well with any of these requirements at the moment, and would require potential disruptive change in order to use it well.

Dominance of 'the expert'

Having framed questions to be answered in a technical way – 'how do we show in practice what Air Cycle can do?' – setting the parameters for the demonstration model and overcoming challenges of building the rig occupied much of the first year. Because the model had to be built using parts given or lent by project partners as their in-kind contributions, the researchers found themselves having to work with components that were less than ideal, which caused them various technical problems. During this period the commercial partners around the table were unable to contribute because they were not technical experts, and were not explicitly invited to offer their perspectives in territory that seemed, to them, to belong to FRPERC and the consultants.

We attended these meetings, and were concerned about the fact that some people were very active participants (the academics and energy consultants) some had limited input (the equipment manufacturers) and some were almost silent (the food manufacturers.) As an attempt to bring different perspectives together to develop a usable Air Cycle prototype, this clearly was not working. With Judith's active support, we started introducing reflection sessions into the meeting agenda, to try and help those who seemed silenced by the technical detail to get their voice into the room. We also discussed the issue with the FRPERC team and with other project partners outside of the meetings, to help them reflect on their contribution to the process and their expectations from it.

Academia seems to be driven by what they think you need to know, rather than helping you solve your problems. In assessing Air Cycle we had to think about how much work is needed to get to the end product. We only need to know enough about the technology to be able to assess its usefulness for us, and how we would deal with it if something goes wrong. It's a fine line.
Food manufacturer

To be honest, this is all going over my head. After the first half hour I started to wonder why on earth I was here. I couldn't understand a word of it.
Food manufacturer

One of the questions was, is this the right group of people to be trying to work on this problem? It was the group that Judith could get in the room, but not ideal. We discussed with some of the food manufacturers whether there were others in their companies they could bring along…

And there is a wider question: is the Link scheme appropriate for this type of development, where a technology is at a relatively early stage and needs to be 'shaped' into an appropriate form in collaboration with those who might use it? Moving a low carbon technology out of a research 'niche' into commercial use is clearly key to the transition to a low carbon future. How could the government help this more effectively?

Power and critical theory

The discourse (language and associated practices) used by a community to analyse a problem influences what is paid attention to, what is 'seen'. This conceptual framing is largely outside the awareness of the communities themselves. Yet it matters in practical terms, because what is seen, and what is seen as important, partly determines what is done. Attention to the use of discourse is part of many theories about processes of social change. The vocabularies we use act like a kind of filter, determining what can be talked about and what cannot. Language, therefore, is a source of power.

There were decisions taken early on in the Air Cycle project which clearly constrained the design of the eventual prototype and potentially affected its ability to meet cost, energy and performance targets. These decisions were mainly taken as a result of constraints imposed by the way that Link projects are structured. It is a complex and costly administrative process to change project partners once the project has started, and there is also a requirement by DEFRA to use UK suppliers wherever possible. At one stage the researchers seriously considered working with

We talked earlier about Mitsubishi and people like that, you know, different manufacturers. In this country we're a bit limited but going further afield in a Link project is a problem. But if you had a lot of money for developing an optimal food system, you could maybe bring in people like that and just pay for the equipment. So it's a bit of finance and politics and it all adds up to make it a bit tricky really.
FRPERC project manager

a Japanese supplier, which may have been technically preferable, but their physical inaccessibility, slow decision making process, and cultural unfamiliarity, meant they were not brought into the project in the end.

Evolutionary economics

Technological developments are time- and path-dependent. Once you go down a particular route there is a tendency to get 'locked-in' to that trajectory, which may not necessarily be the most effective. The Air Cycle rig was being constructed from components that were already developed and used for other processes: it could not be anything other than a development of what is already around.

The communication difficulties, combined with the constraints that came from using components from project partners, had practical consequences. The demonstration rig took the form of a heating/cooling tunnel, designed to take uncooked food products in at one end, and give out cooked and chilled or frozen products at the other. It emerged that the donated components meant the tunnel would have an entrance only 5cm high: when the researchers asked the food manufacturers if anyone had some food that could be tested, it transpired that no one produced anything that would fit into the opening, since they produced cakes, chilled food like salads, and meat products, many of which are steam-cooked and so not suitable.

'Eroding goals'

The food manufacturers were beginning to wonder what they were going to get from the testing process. In particular, they wanted to know if they would be offered something that would be a cheaper process, that would justify some capital expenditure within a short payback period, and in order to keep them involved, the researchers had to promise the possibility of demonstrating better energy efficiency.

I think until we get the system running and demonstrate some real results, I'm sceptical about the energy efficiency that we're going to get and I mean the model doesn't totally convince me yet.
FRPERC researcher

The FRPERC team found themselves having to try and show 'good numbers' that would appeal to the food manufacturers, even though they were aware that they would not be comparing like with like: that if a wider assessment of energy costs, reliability, maintenance costs, and the environmental costs of leakage of refrigerants were factored in, Air Cycle would compare favourably with current practices, but if only direct running costs were used, the financial benefits were much more marginal. So the lock-in to current accounting practices was hindering them from being able to show benefits of the technology.

Nor was it possible to site the test rig inside a company, as first intended, because of practical problems: the equipment which was donated was nowhere near meeting the exacting standards of cleanliness required inside food manufacturing

plants, and it took up space while being non-productive. There was no space for testing and experimenting within the factory regime. So the rig was built and prototyped at FRPERC's premises.

Social shaping of technology

There is a collapsing of potential for the technology taking place at this point. Technological development is partly a social process, subject to the forces of 'interpretative flexibility', where different meanings may be attached to it. Early in a development process, competing social groups may attach different meanings, and the one that invests in it first will have a major influence on how the final design is configured. In the case of Air Cycle, it could be adopted by the food industry purely on the basis of its potential to produce novelty textures and/or products. Thus 'closure' could take place around a configuration in which the potential for low-carbon heating and cooling has dropped out of the picture, and path-dependent development would then reproduce this omission. Preventing these premature closure processes, which interpret potential in the light of what already exists and is 'normal' is extremely difficult.

I think partly with some of the food people it was just lack of space, and there's a perception that if there's a new bit of equipment shoehorned into the factory somewhere it is going to disrupt things… but I suppose we could have pushed and said 'well, let's just stick it out in the yard somewhere' but whether it would work very well out there and could have handled the food correctly I don't know.
FRPERC researcher

Evolutionary economics

Innovation is a distributed process, involving all the players in a supply chain. The demands of the consumer (in this case the food manufacturers) are a significant factor in this process. With Air Cycle, there were certain requests made early on in the project by the customers which became increasingly difficult to satisfy as the design progressed. For example, the customers had suggested a modular rather than integrated piece of equipment, because their cooking and cooling operations are often sited in different areas of the factory. They also wanted the equipment to be small (to fit on a 'skid') in order to fit within their space constrained factories. Had the decision been made to site the prototype in a customer's factory these considerations might have featured more highly in the design process.

Gradually, the partners began to talk about the project as a 'pre-exploitation' project, which in DEFRA's terms would still be a successful outcome. The PMO said that he thought the technology was 5 or more years from exploitation. The researchers suggested to us that in order to show good use of the funds, they needed to get good technical results from the demonstrator, and keep the project partners sufficiently interested for them to be willing, if needed, to take part in a further project

Sometimes I don't want ideas because ideas just mean more work. What I want is solutions.
FRPERC researcher

At the moment I think I'm so bogged down in just trying to build it that I don't really have much time to worry about whether it's going to work or not.
FRPERC researcher

We noticed that discussions about climate change rarely entered the conversation at project meetings. There seemed to be a total lack of urgency about the issue, or concern that the technology might not actually achieve its original objective of reducing carbon emissions. It seemed to us that this particular goal was eroded fairly early on in the design process, as other design issues took priority. Talk about climate and a low-carbon future was only ever initiated by Judith or by us – even though in one-to-one discussions with us, quite a number of partners said personally they were concerned about this issue and would like to be able to think they were doing something to help. Its as if being what one of the project partners describes as a 'closet greenie' is something to be hidden, not quite acceptable as a relevant part of a technology-led business unless it can be presented in the guise of cost saving.

Power and critical theory

The dominant discourse of the sociotechnical regime is one in which a carbon reduction goal is not valid, unless an economic goal is met first.

I don't think the university would even look at the success of the project. … they'd certainly look at the success, if that's the word to use… in terms of money, papers, how many postgraduates we've got or whatever, this sort of thing, but on the level of individual projects, unless it was something really sort of world shattering that they could put on the front page and would be in like all the newspapers, they're not particularly interested in the project.
FRPERC researcher

I don't think at the moment there's anybody biting our hand off for an air cycle system to go into a factory for example, so how keen are they I'm not really sure. Is it like well let's wait and see if somebody else does it, because that's a typical sort of food industry thing. If somebody else has one, we'll have a look at it and maybe then we'll have a go.
FRPERC researcher

Keeping the flame alight

After about a year and a half of the project, the test rig was more or less complete, and the commercial partners began to get more engaged: there was something to look at. Two of the customers sent some of their colleagues to see the demonstrator working, but were uncertain how to place the technology within their particular context, and to see how it could be useful to them.

But since the goals had eroded, the 'success' of the project was now being redefined.

As the project draws to a close a number of organisations, from outside the food industry, have expressed interest in Air Cycle. The industries are interested in widely different applications – from air-conditioning inside low carbon buildings, to refrigeration on board war-ships. Nearly all these inquiries have arisen through some personal contact with the Project Coordinator. She is staying open to all these possibilities at the moment, which fits with her belief that technological innovation is about 'lighting many fires' in the hope that one of them will eventually catch.

From an academic perspective, there was no great incentive for the project to 'succeed' in moving Air Cycle into commercial exploitation – other academic outputs take precedence. But for Judith and some of her team, who have devoted huge amounts of time and energy to developing it, the will to bring it to life remains strong, even if eventual configuration and application is not yet fixed. Judith is continually scanning the environment, to see what commercial applications might be opening up.

Translator go-between and Enabling culture

Several of the 'ingredients' were missing in this project. There was an absence of a translator go-between who could help researchers and industry people understand each other well, and the wider organisational cultures within which participants were embedded were risk averse and far from enabling. However, Judith showed – and continues to show – considerable tenacity and commitment to building a network that will help her.

The potential for Air Cycle to take hold in the food industry may well get a boost following recent reports about the amount of leakage from chiller cabinets in supermarkets. Added to this are regulatory changes which will phase out the use of HCFC's (R22 is the dominant form of refrigerant used in most commercial fridges) by 2015. The hope for the Air Cycle project is that these changes may create a demand for the technology that has so far been missing from the project.

The Environmental Investigation Agency published a report into supermarket refrigeration environmental impact, called Chilling Facts. They surveyed and ranked supermarkets on their attitude to refrigerants. 'Supermarkets are not doing enough to reduce their greenhouse gas emissions according to the Environmental Investigation Agency (EIA). A report from the agency revealed that most supermarkets continue to use gases known as hydrofluorocarbons (HFCs) in their fridges and freezers despite their being 7,000 times more potent in causing climate change than carbon dioxide. The failure of the supermarkets to use more 'climate-friendly' alternatives such as CO_2 and ammonia was 'hugely disappointing' according to report author Fionnuala Walravens. From: www.sirac.org.uk. See Environment Agency report Chilling Facts http://www.chillingfacts.org.uk/

Turbo machinery. Credit: FRPERC

Sociotechnical transition framework

The process of sociotechnical transition as a complex interaction between different 'niches' (in which new inventions are nurtured) 'regimes' (of organisations and institutions that adopt them) and the overarching 'landscape' (policy, regulation, economy and so on). Food retailers occupy a powerful position within the food regime in the UK and probably have the greatest potential to open up 'windows of opportunity' for new low carbon technologies and pull them up from the niche. But their willingness to do so may need to be prompted by pressures from both the landscape and the niche. In this case the media spotlight might lead to 'green' consumer groups becoming aware of the amount of CO_2 emissions from leaking refrigerants and door-less chiller cabinets, and lead them to start lobbying the supermarkets to do something about it.

Our experience of attending recent meetings with retailers and refrigeration experts suggests there may be the impetus to take action to reduce carbon emissions within the refrigeration sector, but perhaps the R&D infra-structure within the supply-base has been so eroded that they no longer have the capacity to respond to the retailers' demands, or at least not in the short-term. In a way, this is quite a sad story. There is a group of dedicated and committed people involved, and a project manager who has devoted huge amounts of her time and energy to try and get this technology to fly – but it's not quite working, and the potential for collaboration is not being realised. Is this process being repeated around the country, in other projects? If so, the waste of resource, effort and time would be staggering.

Thurulie eco-factory

'A wonderful experience'

A jointly told tale written by Gill Coleman with Vidhura Ralapanawe, Rajiv Dharmendra, Ushaan Abeywickrema, Paul Bowes, Rohinton Emmanuel, Rahula Attalage, Thishan Jayasinghe, Chintha Jayasinghe, Sanjeewa Lokuliyana, Akash Hettiarachchi, Asoka de Silva

MAS INTIMATES THURULIE

In 2007 MAS Intimates, a division of a large Sri Lankan apparel manufacturing company, commissioned and built a low-carbon factory, to produce lingerie for Marks and Spencer in the UK. This is the story of how the factory came about, and is based on a learning history conducted at the time.

In particular, it traces how Vidhura, the project manager, became a 'champion', who was able to seize the opportunities of the moment, in a way that enabled the project to become more innovative than it might otherwise have been. In the words of one of the project team, it became 'a wonderful experience'.

In Sri Lanka, 85 percent of the textile industry workforce is female and approximately 350,000 women work in 848 factories. Textile exports total approximately US$2.8 billion per annum, accounting for over 50 percent of Sri Lanka's export revenues.

High unemployment in rural areas and the displacement of people due to the civil unrest means that many young women become their family's primary or sole breadwinner. The women work away from home or abroad to send money to their families. Without bank accounts, the women have to rely on their relatives to protect any cash savings they've acquired until they come home.

In November 2003, a program called 'MAS Women Go Beyond' was launched to empower employees and impact communities by championing the cause of women's empowerment in society. The program also focuses on ensuring employees' career advancement, strengthening their work-life balance and rewarding excellence.'

Compact Quarterly, UN Global Compact, Volume 2007, Issue 1

Vidhura had been waiting for an opportunity to do something 'interesting' at MAS: he had worked for the company for a couple of years without really knowing how he fitted in or what his boss hired him for. He had a background in IT, had studied for an MSc in Responsibility and Business Practice in the UK, and had studied renewable energy and worked in the USA before returning to Sri Lanka and getting a job at MAS, ostensibly to work on communications related to CSR.

MAS Holdings is one of Sri Lanka's largest apparel manufacturers, employing more than 40,700 people in 28 factories in eight countries. Annual revenues in 2006 were US$700 million. Each year, MAS manufactures 50 million bras and is Victoria's Secret's largest supplier. The company is privately-held and owned by the Amalean family.

Chosen as 'eco' pioneers

In 2007, Marks and Spencer launched Plan A, its five year 'eco-plan', containing 100 action points. One of the actions was to work with suppliers to create low-carbon production facilities. In March that year, two Marks and Spencer managers who were tasked with creating at least three 'model green factories' within the first 18 months of Plan A, went to Sri Lanka and asked suppliers there to come up with ideas as to how they could 'green' their production. Sri Lanka was chosen because Marks and Spencer judged they were sophisticated enough to be able to meet the challenge and it was thought they would have some understanding of the environmental issues that were being addressed. In addition, since the garment industry in the country is facing sharp competition from China, low carbon production might offer an opportunity for market differentiation that could be valuable, hence there was a strategic commercial advantage that could potentially be leveraged by the right company. Marks and Spencer were not offering significant financial investment in the plant themselves, or to pay any premium on goods they purchased.

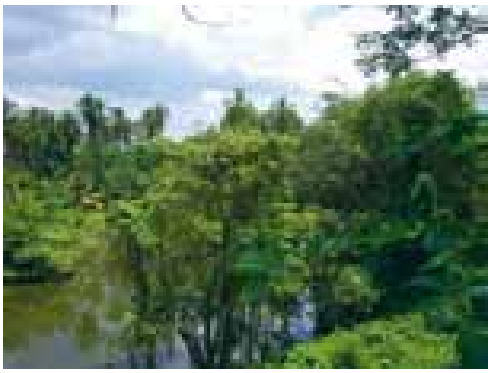
Marks and Spencer wanted to show their belief in the project by creating a strong supplier- customer relationship, through which they identified their name with the goods coming from it. They saw this as a major commitment on their part.

I found it startling that MAS were, in effect, helping Marks and Spencer deliver Plan A commitments at their own expense – making all the investment and taking all the risk. But the MAS business managers were relaxed about this; they saw this as an investment in their relationship with this important customer, and one that made it difficult for the customer to walk away from them, at least in the short term.

Sociotechnical transition framework

The process of sociotechnical transition is a complex interaction between different 'niches' (in which new technological innovations nurtured) 'regimes' (of organisations and institutions that adopt them) and the overarching 'landscape' (policy, regulation, economy and so on). This seems to be an example of an opportunity occurring at the 'regime' level (the taken-for-granted way in which apparel is manufactured worldwide), brought about by anticipated pressure at the 'landscape' level stemming from perceptions about climate change. Marks and Spencer was consciously using its power over suppliers to affect the suppliers' behaviour towards lower carbon production. In so doing, it enabled several aspects of 'niche' technologies to bubble upwards and find form in a newly-configured shape within a factory.

When the challenge was put to MAS Intimates, the divisional CEO decided to create a small internal team to brainstorm possible responses that would move beyond the relatively limited environmental management they had done to that point. It was in his nature to rise to challenges: he was a keen boxing fan (and high-profile supporter of the national team) and liked to tell his staff: 'if you are knocked down once, get yourself up and get back in the fight'.



The site before the factory was built. Credit: MAS Holdings

The factory located beside the lake. Credit: MAS Holdings

Vidhura was pulled into these discussions, because he had some knowledge of renewable energy. This team started thinking about 'greening' an existing factory, and began looking for people with relevant technical expertise to advise them. They found this expertise right on their doorstep, in the Engineering Department of Moratuwa University near Colombo, where a small multi-disciplinary network of environmental enthusiasts had been working together for some years on ideas for low-energy and environmentally friendly building technologies and design. Vidhura had been an undergraduate student in the department some years previously, and was able to make informal contact and test out their capability and interest on the strength of that relationship.

I realised that we actually have the technology and the know-how within the country, and within our systems itself, which are lying dormant, sort of waiting for an expression.
MAS manager

Sociotechnical transition framework

Expertise in several relevant 'niche' technologies had been waiting, as it were, for an opportunity to gain a foothold in the mainstream. The group were not promoting themselves, and had not worked in industry to any extent. Their connection to MAS was simply that one of the MAS managers has been an undergraduate in the school of engineering, and so knew a little about their work. But they had been actively developing their expertise and their knowledge of each other, through collaborating on both academic publishing and practical consulting projects.

The architect and engineers were drawn into the brainstorming process at MAS, and Vidhura found in the architect a fellow-traveller: someone who shared his awareness about climate change and sustainability, and his ambition to do something about it. Spurring each other on, the group decided to explore not just to upgrading an existing plant, but to building a totally new, state-of-the-art 'eco-factory'.

[Vidhura told me] 'They are interested in green building, you have basically a free hand to make a green building, anything you want, it can be done'. I didn't believe it… I have never met a single client who would say I don't want a green building, everybody is for green, but how green is the issue, and what they think green is.
Architect

Relational practice

The importance of 'relational practice' in this story is already showing itself. The group at Moratuwa University were engaged in building their relationships with each other, and the initial approach to them by the project manager was one based on pre-existing relationship. The collective thinking of the informal project group was underpinned by the mutuality they quickly established: they had shared interests, they found they got on well with each other.

Making an icon

With growing excitement, the team presented the idea to their CEO: and he saw the competitive possibilities. It fitted with his sense of what MAS was capable of, what it stands for.

He said, you have to be the best in what you do in this country; I do not want any of your competition being able to do a number on you, you will be the first to do it, you will be the best to do it.
MAS manager

He gave them the resource to work up a full proposal to put to Marks and Spencer. When the Marks and Spencer managers returned the following month to hear the responses to their challenge, they were offered the idea of an 'iconic' new factory, using a brown-field site near a village 60 kilometres north of the capital, Colombo.

> We wanted to make an iconic plant. First, I wanted to be first so that I've got a market edge. Second, I realised that it's not only Marks and Spencer who are moving in this direction, everybody will move in this direction. So, looking at that as a strategy move I realised if you have this iconic plant, it will profile Sri Lanka very well, it will profile the company and the industry very well, it will show our capabilities to the world.
> **MAS MD**

> This had to be a standout factory and truly be green in more ways than one, i.e., it does not just fall in to place for the virtues of green processing, but also it needs to look green in design. So the word is iconic was born from that kind of thinking.
> **Manager, MAS**

> So several things seemed to be combining that enabled them not just to respond to the opportunity, but to 'go beyond', to engage their creativity. Partly it was the company culture and the leadership of the CEO, which prided itself on doing things first and better than its competitors: partly the strategic imagination of the managers, who could see how this might shift their relationship with a key customer and give them commercial advantage; partly sheer excitement on the part of the individuals involved: they had an ambition to do something significant both for their county ('Sri Lanka needs good news stories' one said) and for the planet, and the chance to do so was right in front of them.

Enabling culture

Several of the '10 Ingredients' are apparent at this stage. The enabling culture of MAS, as personified by the CEO, was certainly helpful. A protected space in which the project team could work was created, and resources were made available. Members of this team were diverse – incorporating scientific and commercial perspectives – and together they possessed a keen sense of the larger context and a strong sense of purpose. They felt that this was an important opportunity to show what could be done, in ecological terms.

The Marks and Spencer managers were thrilled with the MAS response, and swiftly signed a Memorandum of Understanding, offering to work with the company to create the factory – sharing expertise where they had it, putting them in touch with technical experts in the UK, and giving lots of encouragement, as well as a financial contribution to the consultancy costs. MAS turned the brainstorming team into a project team, engaged the architect and engineers from the university as consultants, and hired a young architect to work full time on the design.

Stepping up to the challenge

One of the challenges from Marks and Spencer was that the factory needed to be built within a year – so that Plan A progress could be shown to Marks and Spencer stakeholders and to the company's executive chairman, Sir Stuart Rose.

A woman employee. Credit: MAS Holdings

The cutting station. Credit: Peter Reason

But no one knew exactly what needed to be done, or what the specification of the factory needed to be in order to be 'green'. The people from Marks and Spencer had experience of low-carbon stores, but not factories; the team at MAS, had experience of lingerie factories but not low carbon ones; the consultants had experience of low carbon domestic buildings and fitting energy-saving technologies into existing plants, but nothing on the scale of a new factory. So the project team embraced the idea of learning together as they went along.

There are so many interdependencies in doing something like this, is has to be a close-knit team.
Manager, MAS

We were all explorers. One thing we knew going for ourselves is we knew the building blocks were all in place, individually all the building blocks are very sound. The question was, how are we going to put it together?
Manager, MAS

We were trying to understand what is it is we were trying to create – there is no definition, everyone was saying something different, people claim things and they turn out not to be true. We looked at plants in Vietnam, Thailand, Japan, there are no accepted guidelines.
Manager, MAS

The two key individuals were unusually well informed about climate change, and were well aware of the need for significant changes in carbon consumption: their enthusiasm infected others. They were tapping into their highest aspirations for what kind of contribution they could make. This acted as a sort of magnet, an attractor to others involved in all sort of different roles, as the project continued.

Shaded corridor. Credit: Peter Reason

Daring not to know

There was a commitment to take risks together and experiment to discover what they did not already know. The project team were sufficiently confident in their own capacity to realise that if they did not know how to do something, it was because they were taking an uncharted course.

The team started with an ambitious plan, and created a philosophical document to underpin the design and practical decisions, outlining three principal dimensions they would try and incorporate:

- respect for the context (physical, commercial and cultural)
- respect for the user of the factory (particularly the predominantly female workforce who would be sewing the garments)
- and respect for other life forms (the existing ecology into which the factory was being introduced.)

They decided that they would try and build a factory that sat lightly on the land, sited beside an existing man-made lake, making minimal physical impact, and enabling the site to 'return to nature' when the factory was not in use, at night and weekends. They resolved to use traditional, low-technology approaches to managing temperature and water use, drawing on ideas that would be recognisable to many villagers in Sri Lanka. Trees would be planted all around the walls of the building, to create a cool micro-climate, and the roof would overhang to provide shade. Windows would be open where possible to increase air flow and aid natural lighting. The intention was that all the operatives would be able to see out of windows, and have a visual connection with their surroundings.

The design that came from these principles looked unlike any existing factory owned by MAS or any of its competitors. Garment factories are normally large, box-like structures, built on a concrete plinth and with dark roofs, which absorb heat during the day and radiate it into the surroundings at night. In a country where the outside air temperature rarely falls below 30°C, air conditioning is normal, and accounts for around 40% of the fuel consumed. Windows are minimised and sealed, to keep heat out, and cool air in, and the illumination for sewing operations is normally provided by strip lighting. This factory, by contrast, sits on two floors, to minimise its footprint, and to enable the upper story to shade the lower, with reflective and turf roofs to keep internal temperatures down.

The factory is cooled by evaporative cooling – a low-energy process which increases air flow throughout the factory and reduces air temperature by 2-3° only – but combined with the shading, the roofs, the micro-climate and casual clothes rather than formal business-wear, provides a comfortable working environment for people who are habituated to high temperatures and find a 'standard' 24°C specified by international building standards too cold.

Evaporative cooling equipment. Credit: Peter Reason

I mean at 24°, most people in Sri Lanka would freeze, and we knew that…. We tried in the past to change [the international building standard] but it didn't work, and now we have an opportunity to change it, so maybe this time it will work.
Project consultant

There was a conscious intent to push boundaries, including those set in the building standards. Just as Marks and Spencer were consciously trying to influence the supply-chain of which they are a part towards a lower carbon model, the engineers and architects on this project wanted to be able to exert influence to remove blockages to low carbon innovation

Lock-in

One aspect of this is codified in building standards. All over the tropics working environments are cooled in accordance with international standards set to create working environments which are comfortable for people habituated to Northern climates. People in the tropics have to put on extra clothes at work because they find the temperatures uncomfortably cold.

Systemic understanding and timeliness

They were aware that they had an opportunity not only to make a breakthrough factory, but to influence how future apparel factories would be constructed, both in Sri Lanka and in other countries. They consciously tried to use the moment to create an easier pathway for those that followed them.

Other features of the construction are: the use of a re-usable steel framework and timber flooring on the upper floors, solar PV panels, walls and roads built using cement-stabilised soil with low embedded energy, rainwater harvesting, and anaerobic treatment system for waste water.

Overcoming further challenges

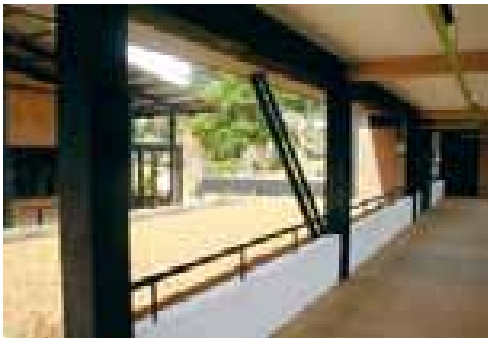
As the design moved off the drawing board and onto site (less than 3 months after the first ideas were hatched), the project team had to be prepared to be flexible while still adhering to their principles. The first challenge concerned certification. Marks and Spencer were keen that MAS get an independent certification of the green features of the building, so the team engaged with the US LEED process, which specifies standards and requires documentary proof and self-audit on six major areas: handling of the construction site, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality and innovation and design processes. Some of these fitted readily to the concepts with which the team were working, but others were very difficult since they incorporate assumptions based on US conditions. LEED specifies, for instance, that a proportion of materials used should be recycled, but good quality recycled building materials are not available in Sri Lanka.

> LEED is made for US conditions… so it's also very frustrating to find equivalent. Sometime we don't have equivalent. So to convince them all the time that it is equivalent, that is tough.
> **Project consultant**

The design features sketched above would lower energy requirements 40% below those of an equivalent traditional factory. But the team also wanted to be using renewable energy for the factory. To do this they negotiated a specific agreement with the Ceylon Electricity Board so that they could buy power from the Association of Small Hydros, since there is currently no regulatory framework for consumers to buy renewable energy.

> It was possible because we are in a large, privately owned Fabric Park, without that none of this would have worked. We could do a lot of things that are not directly in the normal practice of the energy supplier, so that is a huge thing.
> **Manager, MAS**

> The energy supply system in Sri Lanka is another 'locked-in' factor that inhibits low carbon innovation. Although there is expressed intention to move national electricity supply away from the monopoly CEB, there is, as yet, no framework that enables consumers to buy their electricity from anyone else, and CEB generates electricity from imported coal, supplemented with some hydro. But because this is a small country, and the MAS team and their consultants have good personal connections with influential people, they were able to create a special arrangement to supply them with renewable energy.
>
> The building of this eco-factory had wider systemic influences on the 'landscape'. The encouragement of a legitimate market for renewable energy in Sri Lanka is one of these.



Shaded corridors and turf roofs. Credit: Peter Reason

In parallel with the refinement of the building design, MAS was developing its approach to Lean Manufacturing, and it was decided that as well as being a leading-edge building, the new factory should have leading-edge manufacturing processes within it.

Five principles of lean manufacturing

- Specify what creates value from the customer's perspective
- Identify all the steps across the whole value stream
- Make those actions which create value flow
- Only make what is pulled by the customer just-in-time
- Strive for perfection by continually removing successive layers of waste

UK Manufacturing Institute, www.manufacturinginstitute.co.uk

Small hydroelectric scheme. Credit: MAS Holdings

This entailed a further moderation of the building, including removing part of the turf roof because it needed supporting pillars, which reduced the flexibility of production floor space. The project team worked closely with the Lean Manufacturing experts, deliberately trying to integrate their visions so as to provide a 'lean and green' factory, with minimal storage of either materials or finished products, the removal of large automated cutting areas, and production organised in small, flexible sewing teams each working on one garment.

We did change a lot of it. But reflecting back we could see it was true,… I mean we were sort of gone too far in this direction, but we could see that we don't have flexibility…. and the product changes like every season, it cannot be done.
Architect

I think the fact that we were able to make the building very process efficient, to me that was also important, which is probably how the users would feel it. 80% of the users are the factory workers, floor workers, and if they have a view of the building which is very negative, then I think it's not serving the green purpose in a holistic way.
Project consultant

Another problem concerned budget control as the building contractor came on at the start of the building process. Since the design was evolving as more information was gathered, the team wanted the best contractor possible, and approached Sri Lanka's largest, most experienced building firm, which normally does large scale infrastructure projects and housing developments. Although they had never done a garment factory before and the size of the project was much smaller than they usually undertake, they were sufficiently interested by the innovative nature of the project and the opportunity it afforded them to learn about green construction to want to be involved. But they were expensive. The MAS team then had to shift the design again, postponing part of it to a second phase and negotiating a construction contract that made if affordable for them. The flexible approach taken by the project team was matched by the contractors, who found the amicable and cooperative nature of the project very distinctive.

They have a lot of dreams in their mind but some of them are not practical. Some of them are practical. Some of them are very, very difficult to coordinate. Like, my main role comes to get all the dreams and put it into the picture and have a realistic situation which we can build.
Site project manager

At the end of the day what struck me was… this is the first time I'm having site meetings of this nature. Its usually far more aggressive – you should have done this, why didn't you do that, that kind of thing. Here it's not like that, here even if something is not done we sort it out in a reasonable way – I thought that was a very good approach.
Construction company

Green and reflective roofs. Credit: Peter Reason

Here we can see the 'attractor' factor: people – like the main contractor and various sub-contractors on site – wanted to be involved, wanted to be part of something exciting and innovative. Few of them had much sense of the facts of climate change, or the strategic significance of what they were doing, but they liked the sound of what they heard, that it was a 'green' project.

In April 2008, barely a year since the idea had first been put to MAS, the new factory was opened by the Marks and Spencer executive chairman, and commercial production began the following month: the challenging time-frame set by Marks and Spencer was met. There is little doubt that Marks and Spencer are delighted with it – the factory features in their Plan A website, and the lingerie from the factory can be found in Marks and Spencer stores bearing the label 'This garment has been made in an eco-factory'. Although MAS have no contractual agreement promising them security of custom, they know that they are now a key part of the Plan A achievement Marks and Spencer want to demonstrate to their stakeholders, so the customer needs them as much as they need the customer.

There are some social complexities lurking within this account, which I became aware of. As a Western female action-researcher, I notice the stark nature of the gender relations in Sri Lanka. The factory is in a rural setting, where jobs are generally scarce and incomes are low. Most women perform a traditional social role, centred on marriage and child-rearing, but also share the burden of making a living for their family. Aware of the challenges faced by their predominantly female workforce, MAS run a sophisticated women's development programme (Women Go Beyond) and are seen as an exemplary employer. Nevertheless, working in a garment factory acquired a negative social image in recent decades when sweatshops were common, and although employment practices have improved women workers and their families still have to weigh the benefits of the income they can earn against some lingering social stigma, and impact on their marriage prospects, that are associated with such work. And all of this takes place within the 'landscape' of a worldwide consumption-dependent economy, based on global supply chains which involve shipping goods around the world. A story brings its complex social and political context with it – and this, too, is part of any low carbon future that may be being created here.

Furthermore, the factory has generated a lot of interest among other suppliers and other customers. Marks and Spencer bring suppliers from other countries, notably China, to visit the Thurulie factory, so that they can see what is possible and be inspired to create their own innovation. MAS have taken both managers and customers from their other divisions to see the factory, and are actively working on how they can use what they have learned from this project to bring their other garment factories to a similar environmental standard.

Translator go-between

In all of this, the project manager's role has been crucial. Because he had relevant knowledge, he was able to talk to the technical consultants in their own terms, and translate what they had to say in a way that his business colleagues (and his Marks and Spencer customers) could understand. His focus and enthusiasm were a factor in Marks and Spencer choosing to back this proposal in the first place, and he developed a shared vision with the senior architect that enabled them to ground the project in ambitious and holistic principles of sustainability which are much broader than simply reducing energy consumption. They both aspired seriously to create an icon, and exemplar as to what is possible, with imagination, in a strongly commercial environment. Building on their shared enthusiasm they were able build a coalition at many levels which had political and financial support and enormous enthusiasm and hard work from all involved.

Relational work

The significant relational work continued. Vidhura and his colleagues created and sustained their vision through close collaboration, learning together, mutual support and problem solving. Importantly, they were able to mobilise their relationship to hold the scope of their ambition for the factory, in spite to frequent practical challenges.

It is also possible to map this story against the Complementarities matrix showing that there were positive qualities present at all levels in this story – subjective and objective, individual and collective – which reinforced each other.

Production floor. Credit: Peter Reason

Gill and Vidhura. Credit: Peter Reason

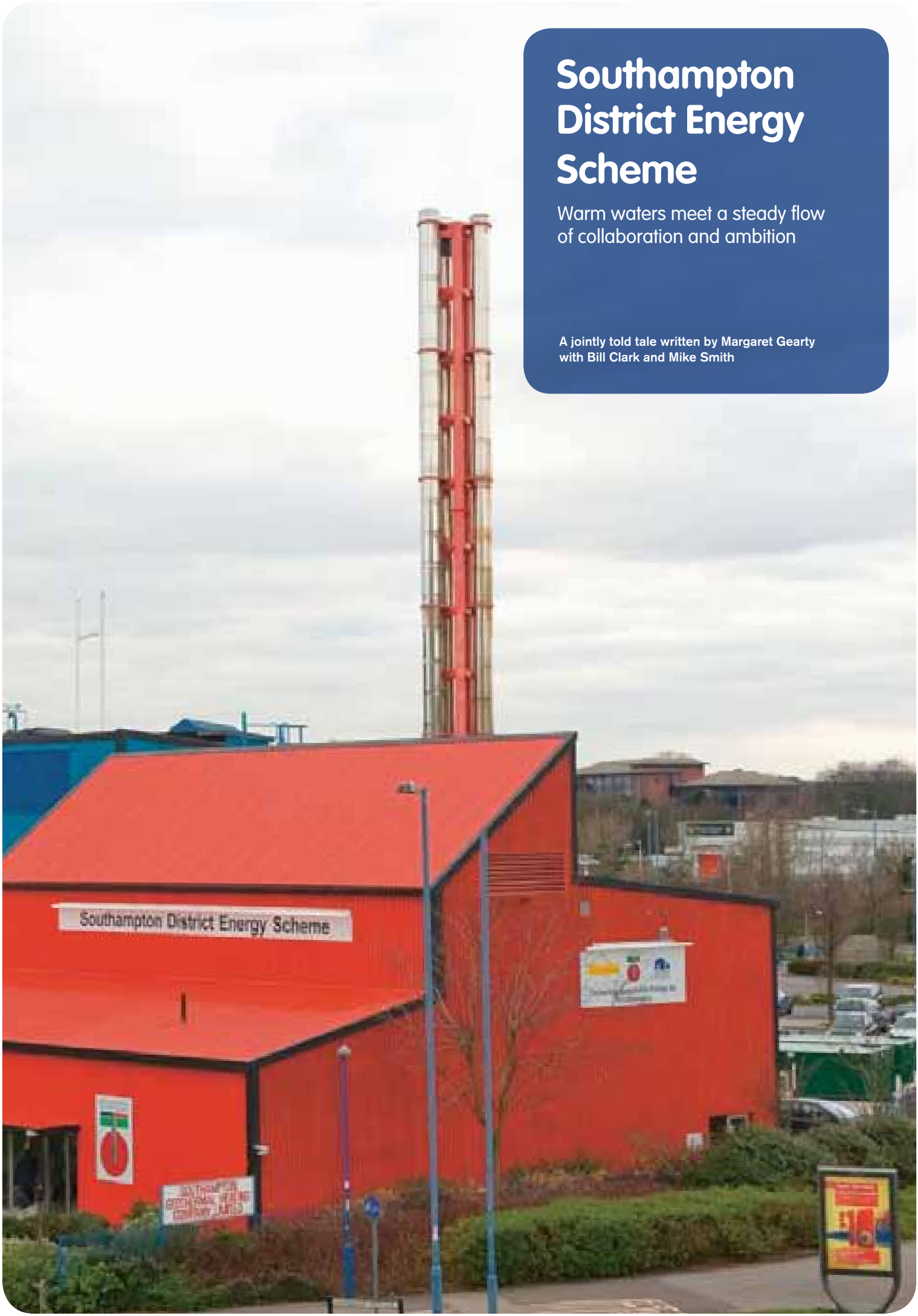
I learned one thing: as a designer you can't do on your own a green building. To do a successful green building you need others' feedback as well… So that's how I learn right throughout the process. Actually, my idea of the green buildings – it has to be always – should be a collective thing, not an individual one person. So likewise, it's exchanging ideas and it's a different – actually a wonderful experience.

Project consultant

Southampton District Energy Scheme

Warm waters meet a steady flow of collaboration and ambition

A jointly told tale written by Margaret Gearty with Bill Clark and Mike Smith



Every six weeks or so the joint technical team from Southampton City Council (SCC) and from the energy services company Utilicom, the UK subsidiary of the French company Idex, meet. Together they pore over a large A0 printout that shows a plan of the city with red lines linking several buildings and the start too of a network of blue lines.

The red lines represent some 11 kilometres of well-insulated underground pipes that supply heating to over 40 sites, including private and social housing, commercial offices and retail outlets, civic buildings, a hospital and hotels.

In the region of 12% of this heat comes from hot water pumped from a geothermal well in the city. The rest comes from highly efficient dual-fuel (gas/oil) combined heat and power generators (CHP). Conventional boilers are also connected as backup for breakdowns or peaks in demand. The blue lines represent the chilling mains.

A0 print out of the Southampton scheme.
Photo: Margaret Gearty (MG)

Heat station in red and blue.

NB: All photos of the scheme courtesy of Southampton City Council/Utilicom unless otherwise attributed.

The heating (and cooling) scheme has been steadily developing since the mid-80s and now saves customers some £350,000 in annual energy costs and reduces carbon emissions by some 11,000 tonnes each year. Those connected to the scheme enjoy reduced capital and running costs compared with conventional systems.

Neither district energy nor CHP is new, but these carbon-saving technologies are under-used in the UK. Whilst more than half of today's Swedish, Finnish, Danish, Polish and Estonian homes are connected to district heating systems only an estimated two per cent of UK homes are heated in this way.

In the post-war property boom of the 60s and 70s some 500 schemes were installed, largely on new housing estates and predominantly in council housing. But frustrated by poor performance, inaccurate meters and the lack of individual controls, many council tenants lobbied successfully to have themselves disconnected from what came to be perceived as poor man's heating. Old, unused pipework still runs under many UK cities. Nottingham boasts the largest district heating system in the country and is run off the local waste incinerator.

Southampton is the largest non-waste driven scheme in the country. It makes use of the latest technology: lagged pipes ensure just a four per cent heat loss over the entire system. Proper backup boilers and isolation rings minimise service disruption. Accurate meters offer fairer billing, at household level if necessary. And state of the art CHP engines boost the overall capability of the scheme. The scheme is thriving, with a steady uptake in connections from across the private, public and domestic sectors.

Social shaping of technology

An interesting part of this story is in how Southampton has distanced district energy from this troubled past. It represents the new generation of community heating in the UK. The scheme at Southampton could be described as a re-shaping in action of the meaning of district energy in the UK. This history highlights some of the social processes of re-negotiation that accompany a change in the meaning of a technology.

Some may argue that Southampton's access to geothermal energy makes the system hard to replicate elsewhere. Yet the hot waters in the aquifer below Southampton contribute just over a tenth of the heat in the system. And as this learning history will show, the geothermal element is just one aspect of a scheme that over 20 years has been built up through steady vision and collaborative partnership.

I was interested to discover what role the geothermal resource played. Could the scheme have happened without it? And what, if anything, is stopping similar schemes being built elsewhere?

Heat pipes being laid. Modern pipes minimise heat loss.

Perspectives

Many people have been involved in the Southampton scheme ranging from politicians to commercial partners, clients and end users.

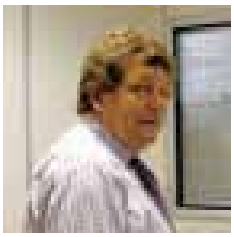
This narrative is told from the perspective of Southampton City Council and focuses particularly on the early history of the scheme.

It draws on conversations with two people who have been closely involved and whom I met during 2007. The first is Mike Smith, a former finance director from Southampton City Council who was central in setting up the scheme in the 80s and running it subsequently. In 2006 he left the council to become a director with the scheme's commercial partner, Utilicom.

The second is Bill Clark from Southampton City Council. Bill joined the council some 26 years ago as a landscape architect and played a key role in its successful 'greenways' scheme to safeguard open spaces and the environment in the city. Bill first got involved with the geothermal heat scheme in the mid 80s and in 2006 took over its running and promotion from Mike.

Quotes from Bill and Mike are spread through this learning history.

Mike Smith, Commercial Director, Utilicom. Photo: MG



Bill Clark, Sustainability Policy Manager, Southampton City Council. Photo: MG

Phase 1: Well explorations and shifting landscapes
Late 70s to early 80s

Concerned about energy supply and security during the fuel crisis in the 70s, the UK Department of Energy set about digging four wells to investigate the potential of exploiting local geothermal energy. One of these was at Marchwood Power Station, across the estuary from Southampton city.

The well was total serendipity.
Bill

I was looking at it purely as an accountant: this sounds expensive and a bit risky, I'd better keep an eye on this, which I did.
Mike

The finance director of the council at the time, Mike Smith, was keen to understand what the government was doing so he and the city architect headed out to Marchwood to have a look. The well there demonstrated that below Southampton, buried deep in the Triassic sandstone, lay an aquifer of hot water. The water would be used at the power station, but it clearly had a wider potential as a heat source for the city.

But the original impetus behind the project started to fade. The power station at Marchwood had been closed down. And with cheap gas allaying original fears about energy supplies, the government planned to cap the well off.

Convinced of the geothermal potential, however, Mike wasn't ready to let it go just yet. He set about persuading the Department of Energy to go ahead and drill the second well in Southampton and to test its potential to heat a planned redevelopment of the city centre at WestQuay.

And it took a lot of convincing.
Mike

Wide vision

Notice how Mike moved from risk assessment to spotting an opportunity outside the immediate professional environment.

So that energy security agenda of 30 years ago has come full circle again and is now joined by climate change. I wonder how what we are doing now will fit with agendas in 30 years time?

Mike's growing interest in the environmental potential of Southampton's geothermal resource mirrored an increasing awareness at the council of the importance of environmental issues. A number of 'green-minded' politicians championed an agenda that they saw as politically but also personally important. Significantly, these champions were drawn from across the three political parties, a factor that was carefully acknowledged and that would prove significant in maintaining support in the years to come. In the mid-80s, Mike's work started to dovetail with Bill's environmental work at the council.

Diverse coalition

A recurring theme in this history. The project continually drew in people with different capital – in this case political capital – to strengthen it.

This political support at Southampton was vital in helping Mike lobby the Department of Energy to fund the second well to explore if it might be commercially viable. Eventually they agreed. A production well was drilled with a view to providing heat to the forthcoming city centre development.

They dug this pit. …next to where the rig was going to be, and that evening it filled up with water so they brought a pump in and pumped it out, and the next morning it was, it filled up again and it took them two days to realise that every time the tide came in they were effectively pumping the Solent as the ground water level was so high!
Mike

Norman used to come up to the Department of Energy with me to negotiate and I can remember being there quite late at night negotiating with them.
Mike

An interesting juxtaposition? The well cap in the Toys'r'us car park.

The cool accountant's eye seems necessary so as not to be daunted by the sheer scale of a scheme like this or the lack of technical expertise – they learnt as they went.

However when geologists tested the commercial viability of the well they found a bounded, wedge-shaped aquifer that would take increasing energy to pump. In short, their assessment said it would not be viable in the long term and that it wouldn't support a large scheme. The Department of Energy now withdrew their financial backing completely.

Were you gutted at this point?

Oh we were, and we'd put in a lot of time and effort. I must admit I'd changed from a sort of cynical and sceptical accountant to a very enthusiastic environmentalist.
Mike

Mike's shift to becoming an environmental champion is interesting here. The environmental agenda seems to transcend other organisational agendas that might have led him to leave it alone.

Mike and others at Southampton now didn't want to let go so quickly and wondered whether the aquifer could still be used for a smaller scheme. Perhaps. But they were now completely on their own. Even if a smaller scheme was run, further testing of the well needed to be carried out costing around £600K-£800K. It was going to be expensive.

At that time I don't think we understood the potential. It's only subsequently that we saw [it].
Mike

Tenacity / daring not to know

This is an example of the tenacity, passion and faith without answers that repeats throughout this learning history.

Now an advocate for geothermal energy, Mike was invited in the early 80s to speak at an EU geothermal seminar in Italy about Southampton and the original vision they had for the scheme.

Over coffee during the conference, he chatted about the second well with a Greek and an Italian delegate, inquiring casually about the possibility of getting EU funds for the testing. As it happened, his inquiry was well-placed. His fellow coffee-drinkers were well connected in the EU and were optimistic about the possibility of getting funding. They invited him to come and explore it further with them in Brussels.

So that's what I did, this was just over a cup of coffee and I went across to Brussels and from there they very kindly agreed to find funds to test the well.
Mike

I find these chance moments interesting. They are not really 'chance' so much as an individual's unswerving vision creating possibility wherever it goes.

In Brussels, the EU funding was agreed. They were now on unchartered territory – there was no experience in the UK for a project like this.

Sociotechnical transition framework

There is an interesting interplay in this story between different levels of sociotechnical activity. It was early macro-political pressures at the 'landscape' level that stimulated interest in the geothermal resource in the first place. However this was then withdrawn. The pursuit of geothermal energy then became a 'niche' agenda that required re-negotiation at the level of the sociotechnical regime.

Phase 2: Partnership: Sharing knowledge and risk
Mid-80s

If you haven't got the expertise, you buy it in. You're always looking for risk transfer.
Mike

The technical operation of the well was a responsibility that Mike was keen to transfer, along with the financial risk, to a private sector partner. Taking the pragmatic view that missing expertise can be bought in, Mike started talks in the early 80s with French company Utilicom, who had already put a number of district energy schemes together in Europe in the 70s.

They [Utilicom] take the financial risk and we [SCC] take the reputational risk.
Bill

It seems important to know how to 'place' and 'locate' knowledge and skills rather than to actually have them.

A good working relationship with Utilicom began. The then director, Charles Maillard, could see the commercial potential despite the real financial risks and with his support, a trusting, collaborative way of working developed.

As the tests on the well verified its potential, Mike and the council's lawyer of the time, Jacqui Dixon, set about drawing up an agreement as to how the council and Utilicom might do business together.

The two people [who] can usually kill schemes [are] an accountant and a lawyer. So you've got me on the one side sort of the champion and on the other side Jacqui who really grasped this.
Mike

This required detailed financial, legal and organisational effort and a whole new way of working for both sides. The key principle was that the partnership would be founded on co-operation and trust, so Mike and Jacqui Dixon worked up a non-adversarial legal agreement to reflect this.

Social shaping of technology

Note here how the move to a new technology for heating also necessitated a shift in legal and financial ways of working. Sociotechnical theory makes the point that technological innovation cannot be considered in isolation.

The resulting agreement captured the spirit of what the partners intended to build together and has, Mike says, 'stood the test of time'. Over 20 years it was barely referred to and it recently formed the basis for a renewed 25 years of partnership from 2005.

The best contracts go in the drawer and you don't refer to them because it's the people that make them work. It really is.
Mike

Confidence and support for the scheme was high in the council and in 1987 the agreement was signed. A company wholly owned by Utilicom – the Southampton Geothermal Heating Company (SGHC) – was formed to run the scheme. Credit was carefully given to all the political players involved.

Enabling culture

A culture of proactivity was being created by people high up in the organisation. Trust seems to have underlined this culture both inside the council and in their commercial partnership.

I used to make a point of saying, this Conservative member, this Liberal Democrat member, this Labour member … So they could all take some kudos from it… After every election we'd have a seminar for members and bring them down here [to the heat station].
Mike

A 'joint co-operation' team chaired by Mike was put in place and from the start the team shared a belief in the scheme which was reflected in how they worked together with a sense of shared ownership. This inter-disciplinary team included, amongst others, a civil engineer and a planner from the council, and from Utilicom, Charles Maillard. These and others came on board and drove the scheme forward with enthusiasm.

Diverse coalition

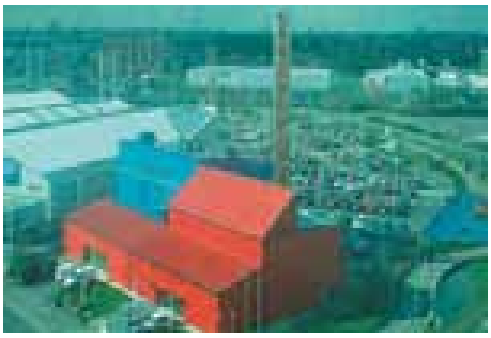
This team is a classic example of a diverse, flexible, project-focussed coalition bringing different knowledge domains together.

A vibrant visual identity soon started to emerge, matching the enthusiasm. Bright blue and red colours were chosen for the heat station and a competition was held to design the company logo. It was an exciting project – one of the first of its kind in the UK. And echoing the principles of the legal agreement, the atmosphere was again collaborative and non-adversarial.

It was funny because the way this team came together, it's one of the best teams that I've managed. They seem to identify with the project … it was really 'how can we take this forward?'
Mike

There seems to have been a special quality of relationship in this team that is more akin to friendship than organisational team work. Mike mentions they still keep in touch.

With a commercial partner on board, things moved quickly. In 1986 the red and blue heat station was built just a few 100 metres from the well.



Southampton heat station: opened in 1986.

Briney water is pumped out here. Photo: MG

Phase 3: Winning connections – Forces of resistance 1986 on

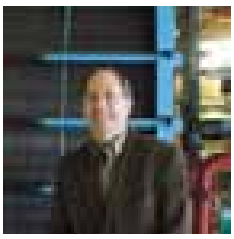
Briney water began to be pumped out of the well and passed through a heat exchanger that Mike had rescued from Marchwood power station.

> Ignorance is bliss because I hadn't a clue how much these things were worth. And I think I offered them something like about £500. I didn't know how big it was, I think it cost us more than that to transport it and to store it!
> **Mike**

Daring not to know

Mike's entrepreneurial move is typical throughout the story. Not being afraid of the technology and accepting they just needed to have a go liberated the team to get on with it.

Mike with the titanium place heat exchanger he bought at a bargain from the Marchwood well.



The resulting clean warm water, together with hot water generated from the first 1MW CHP engine, was pumped through pipes to supply heat to the first customer of the scheme. Located just over a kilometre away – that customer was the Civic Centre.

With that first connection the scheme proved it worked.

> Getting the capacity to build infrastructure is probably one of the most important things. But start it off from schools, leisure centres, which can justify putting a CHP plant in.
> **Bill**

Equally significant would be the second connection.

> The stepwise approach is so important to innovate with a huge capital project like this. The council having its own building was crucial. The large estate they control is a reason that gives councils the opportunity to trial new approaches.

ASDA's connection for heat takes much less space than a boiler room.

In late 1988, ASDA, a large well-known supermarket chain, was one of the first to put in plans for development near the heat station and with that application the Council had its first opportunity to demonstrate how serious it was about the scheme.

As a new-build, there were strong arguments for ASDA to connect. Not only would they save money, but extra retail space could be won by not having a boiler room. But, as the partnership were to find in the coming years, strong arguments weren't always enough to win customers.

> I wouldn't say it was easy – it is a lot easier with new build than refurb…. We used the planning; we just encouraged them through the planning system.
> **Bill**

ASDA did finally agree to connect and that was significant. It was one of the first commercial businesses in the UK to connect to district heating. Furthermore its location on the land near the heat station was important, as it set a precedent for the developments that were to come. For the joint team, it probably also marked the beginning of a journey of highs and lows as they sought to entice new customers to connect to the scheme.

Is there a celebratory moment when someone says they'll connect?

No, well, usually it's thank God for that!
Bill

The cost advantages of connecting to the scheme were persuasive from the start but it was never going to be that simple. In so many ways the scheme challenged, and indeed still does challenge, 'the way things are done', and the response to this challenge ranges from puzzlement through to downright obstruction.

We have a view here, and that is that the people who specify energy systems in buildings are very reluctant to support district heating schemes because their fees are reduced….
Bill

Along with all the natural concerns about the reliability and operation of a new technology ran some more deep-rooted patterns of resistance. By proposing a new way for heat (and later cooling) to be supplied, the scheme was challenging all the practices, policies and organisations that have built up around that idea of heat supply. Gone would be a boiler room and with that the need to design it. Gone would be the need for wall-mounted electric heaters, but what if a company-wide procurement policy was ensuring cheap supply of these radiators?

And the benefits of connection sometimes accrued to those who would operate buildings, but not to those who commissioned and designed it.

Lock-in, sociotechnical transition and bounded rationality

With a sociotechnical change of this scale, resistance will be evident at different levels. When individuals want to carry on doing what's familiar even when changing would be advantageous, they demonstrate a kind of 'bounded rationality'. Similarly organisational routines contribute to a 'lock-in' of overlapping procedures that makes change difficult. In sociotechnical terms, the Southampton project was challenging an interlocking regime of how heat was conventionally supplied to, and used in, buildings.

The role of the Council in promoting the scheme was also challenging the common view of how development was done.

The general view is… what the hell is the local authority doing trying to get us to do this? We want to get this building built – why are we talking about how we're going to heat it and put energy into it?
Bill

A fine balance was needed between encouraging and forcing connection. In those early days, there was little leverage to be drawn on. Connection to the scheme was presented to developers as much as a 'moral obligation' (Mike) to the community and the city as it was a financially advantageous proposition.

Negotiation was a delicate and sometimes protracted process. Relationships needed to be carefully built and it was a blow when, despite everything, a customer didn't carry through the connection.

You get disappointed when you lose. There've been one or two [failures] where I've almost taken it personally because you invest so much time and effort in it.
Mike

When have you had sleepless nights?

Failing to get major developers on board – and wondering why.
Bill

With each successful connection though, the scheme grew in reputation and legitimacy. The BBC connected in 1990 and though local hotels appeared reluctant, French hotels IBIS and Novotel connected without a murmur a few years later.

Finally in 1994 the new five star De Vere Grand Harbour hotel agreed not only to connect to the heat system but to take advantage of the chilling that was made possible by an absorption chiller at the heat station. Costs for the new infrastructure were shared between the hotel and the scheme.

The luxury De Vere Grand Harbour Hotel connects for heating and cooling in 1994.

This sharing of the capital infrastructural cost reflects flexible financing and the ability to accrue cost-savings on a whole-life basis. It stands in stark contrast to the forces of lock-in mentioned earlier.

The scheme could now demonstrate capability in chilling as well as heating and the impressive façade of the luxury hotel put paid to any lingering associations between this district energy scheme and 'poor man's heating'.

Social shaping of technology

It is interesting the French hotels played this important role. District energy is common in France and it is likely cultural acceptance made connection easier for the French hotel chains. So lock-in was broken in places and in so doing the meaning of the technology was being re-negotiated locally. The luxury hotel connection was significant because it challenged deep-rooted cultural resistances to district energy that may have underpinned some of the resistant forces.

That was one of the lightbulb moments and you think, yes, it's the network really that's important, after that you can plug in whatever energy sources you've got really. And so it was then we realised that our dream of having a large scheme actually, we could do this by adding CHP even though the geothermal resource was relatively small.
Mike

Phase 4: A lightbulb moment – Expanding the vision

In the mid-90s the focus and understanding of the scheme started to shift. Though it was and still is marketed as a geothermal scheme, the importance of the geothermal element was becoming less central. Gradually Bill, Mike and others were realising that it was the network and not the actual heat source that was important.

This shift in thinking was significant. It reconnected the team back to their original ambition – that of a larger district energy scheme around Southampton. This had been curtailed by the limited size of the aquifer, but now the vision was re-instated.

This liberated the team to think more imaginatively about potential sites for community energy that were further out and that didn't have a direct connection to the geothermal well.

One such site was the Holyrood council estate where 300 council flats needed new heating. Too far from the well, a small on-site CHP generator was installed instead and this supplied a standalone community energy network around the estate. This demonstrator then paved the way for connections to private residential clients and dispelled the belief that geothermal was essential to the growth of the overall scheme.

Holyrood council housing: site of the first standalone CHP scheme.

Amplifying feedback

At several points, and this is one, steps taken on the project broadened its scope overall. The connection of Holyrood created the possibility for the scheme to expand into residential and standalone schemes.

The role of the geothermal resource was gradually being reshaped. It was now understood more as a catalyst for the scheme rather than its key substance and this process has continued over time.

The geothermal, it's like the marketing expression really, it's the sizzle that sells the sausage.
Mike

It's a catalyst for changing agendas.
Bill

The Holyrood estate showed that putting CHP into high energy-use complexes would be a sensible starting point for any local authority or estate manager looking to reduce energy and carbon costs. Doing this at Southampton required neither geothermal water nor the infrastructure of its district energy network, though there can be no doubt these created the culture of trust that enabled Holyrood.

What would it take for an organisation without those catalysts to connect a high energy-use complex to combined heat and power? What stops leisure complexes, for example, all running on CHP?

Phase 5: Growing, energising and expanding

With success and expansion came growing pains. New connections increased the demand for energy and it was still a struggle to become profitable. In 1996 Simon Woodward was appointed as Chief Executive of Utilicom. He brought to the partnership technical and business skills that proved invaluable in helping to expand the scheme, energise it and make it profitable.

A timely appointment. Becoming commercially viable is not a straightforward step. There seems to be a pattern of easy and appropriate switching of the championship role throughout this project.

Under Simon's leadership, an enormous 5.7 MW Wartsilla CHP generator was installed at the heat station in 1998 to boost capacity.

And another landmark was reached in 1999 when Barratt's Homes agreed to connect a new development of over 100 luxury apartments to the scheme. Parkview would be the first private development of its kind in the UK to have community heating. Customers would have individual heat meters in their homes, long-term contracts with the supplier (20-25 years) and index-linked guaranteed savings over time. It was an entirely new way of doing heating. Customer feedback has been positive, with 69% rating the community heating system better than the old system. Customers liked instantly available hot water, although a few complained about being locked into long-term contracts with one supplier.

The 5.7MW Wartsilla engine being delivered. It was so big it stopped traffic on the M25.

Parkview luxury apartments connect to the scheme in 1999.

Interesting to get this insight into how users' practices have changed in response to a change in technology/service. In such situations consumers just seem to adjust and get on with it. But I wonder whether they would opt to change to such a system deliberately? Consumer choice is complex.

The system was proving very reliable. There were back-up boilers at the hospital and in the civic centre. In the lifetime of the scheme only four outages have disrupted supply. Two outages were caused when pipes were accidentally damaged during building works. Customers, contractors and builders simply forgot they were there. And during a cold snap in March 2007, the civic centre heating system broke down for the first time in 20 years. On investigation it transpired that it was the civic centre's 1930s cast iron pipework that needed repair, not that of the energy scheme. Customers' responsibilities are different with this scheme. It takes some time to adjust to and understand the difficult shared responsibilities. Isolation rings minimise the impact of these kinds of problems on the rest of the system.

The civic centre was off for 3 days, which meant that… Yes it was…
Bill

It was really in your face?

The unit of breakdown is greater with a system like this. The social effect of 'many' unhappy customers could have a disastrous effect on the image of the scheme. The scheme makes the interdependence of those connected more obvious… perhaps no bad thing?

A bank of vapour compressor chillers bring the current chilling output to 8MW. Photo: MG

By 2000, the once derelict land around the heat station had been redeveloped into a large shopping centre at WestQuay. Many outlets including big name retailers such as Marks and Spencer and John Lewis agreed to connect for heat as well as cooling. Vapour compressors were installed at the heat station and these used electricity from the CHP engines to drive a much greater capacity of chilled water. So the regenerated area was now connected to Southampton's geothermal's water.

With this achievement, the original vision that had led to the digging and exploring of those wells had been realised and not only that, it had aligned with the 21st century agenda of tackling climate change.

Conclusions

In 2008 Southampton and Utilicom celebrated the 21st birthday of the scheme. With continued plans to expand in the future, Southampton is gaining increasing recognition regionally, nationally and internationally.

Southampton has been invited to present to Government departments and they have also actively sought to influence government policy, contributing to the Energy White Paper, the Local Government Act among others.


US Mayors share in city energy vision

From Southampton 'Cityview' magazine, Issue 50, January 2008.

And in Europe, too, their profile is increasing. Their links at that level have always been strong and the team works hard to raise the scheme's profile in that market. As much as they visited (and continue to visit) sites in Europe, people from the UK and abroad now come to visit them. Whereas they participated in the European networks – Energie Cities and Eurocities – originally to learn, now they are invited to seminars to present their scheme as an example of best practice. The relationship with Europe is at once inspiring and gratifying, as illustrated by Bill's description of a recent visit he paid to a huge CHP-Geothermal project near Zakopane in Poland.

> I say… oh that's a good system… how big is it… they say 'we've got 100K of pipe' and I think 'we've only got 11!' And I said what's the power output? They say 42MW. And I think 'gosh – ours is less than 10!' I thought this is going on in Europe, big new technology that is going on there and it's partly drawn from our experience here in the UK.
> **Bill**

External networking

An openness to collaborative learning underpinned the project and this was exemplified in how the project made links locally as well as to geothermal networks in Europe. And amplifying feedback has boosted the project's prestige and influence.

All this influence is a source of kudos for the scheme that is appreciated but not actively sought. I had a sense that what is most rewarding for those involved in the scheme relates not to fame but to the wider purpose of tackling climate change, what they now call 'the change' (Bill). Framed this way, the success that is sought is the scheme's extension and proliferation. Marketing is done with this in mind, which may explain why at a national level, the scheme is less well known, whilst at the same time its ideas are spreading.

In the UK, via Utilicom, Southampton's pioneering scheme is being directly replicated with proposed schemes in Birmingham, Eastleigh and elsewhere. It is not just the pipes that are being replicated but also the whole way of working – from the joint co-operation group to the financial models.

> Now there is a big Birmingham scheme and there'll be other big schemes as well. The Southampton team did the pioneering work and they are the people that really sweated and had the commitment and took the risk. They shouldn't be forgotten.
> **Mike**

Characteristically Mike is ever concerned that the original innovators enjoy a share in these new successes. Replication is, in its own way, a testimony to the fact that the capacity developed here over many years is ready to flourish into capability elsewhere.

Relational practice

The success of the Southampton example seems to build on strong relational work. It exemplifies new models of 'postheroic' leadership that recognise that in 'knowledge-based environments leadership relies less on the heroic actions of a few individuals at the top and more on collaborative leadership practices distributed throughout an organisation' (Fletcher). Southampton shows how this kind of leadership is expressed through a distributed group of people whose capacity to interact in relation to each other dictates the quality of their collective leadership.

Sociotechnical transition framework

Southampton confirms the sociotechnical view that change erupts rather than being carefully or strategically controlled. The geothermal niche was first created by strong landscape pressure (the fuel crisis). The niche was then pursued by the tenacity of individuals and coalitions from within the sociotechnical regime who tried to move it forwards. It was these coalitions' clout and work within the regime that brought about change, rather than the technological strength of the geothermal niche. The history shows, too, how technological change requires a simultaneous shift of interdependent market, user, financial, legal and cultural factors. The relational work in the regime helped address existing cultural barriers to district energy and to break locked-in fossil-fuel dependent approaches to how our building stock is heated and cooled.

Theories

What we need are multidimensional studies of real change in whole domains of practice, looking at the domain as a system rather than just at individual technologies.
Fred Steward, 2009

Introductory comments

In this section we explore some of the ideas that have informed this research project. We have attempted to present key theories in an accessible manner with some references for further reading. We have also pointed out key links between the theories explored here and the earlier narratives of low carbon initiatives.

> Herbert Simon, who coined the term 'bounded rationality', used the metaphor of a pair of scissors, where one blade is the 'cognitive limitations of actual humans' and the other the 'structure of the environment'. Minds with limited time, knowledge, and other resources can be nevertheless successful by exploring structures in their environments… Studying only one blade is not enough; it takes both for the scissors to cut.
> **Gigerenzer & Selten, 2002**

> Nelson and Winter [develop] the concept of 'routine'. A routine could be any technical, procedural, organisational or strategic process or technique used by a firm as part of its normal business activities, for example, its R&D strategy.
>
> Routines change by a process of searching for better techniques. Successful routines, and firms that employ them, are then selected by the process of market competition. Because firms are assumed to have 'bounded rationality', search processes will usually look for incremental improvements in techniques or imitation of the practices of other firms, and will be terminated when firms satisfice by attaining a given aspiration level. So, any equilibrium reached will only be temporary and cannot be assumed to be optimal or maximally efficient.
> **Foxon, 2003**

Underlying all our thinking is the perspective of **evolutionary economics** which articulates a broad critique of classical economic theory. Classical theory has been built on an idealised view of human behaviour. It assumes humans to be entirely rational. When faced with a decision, an individual is presumed to find the available relevant information, process it rationally and act accordingly. But what are the implications of these idealisations? After all, theories, be they exploring an organisation, a society or a political system, need to make simplifications. However if theory fails to account in any real way for the phenomenon of human behaviour, it runs a risk of building an edifice on shaky foundations. At best such a theory runs a risk of becoming hermetically sealed into itself and difficult to translate into practice.

Evolutionary economics sees decisions as taken with 'bounded' rather than perfect rationality. Choices are not made with full information and full rational calculation, but through a **'bounded rationality'**: decision-makers are subject to the limits of their cognitive processes and the circumstances of their environment. Rational models of decision-making are not helpful because people simply may not have the time or the mental capacity to process all the information at hand. Or indeed their environment may be such that they cannot or will not seek that information out. So rationality can never be optimum, but is always 'bounded' by the constraints of perspective and circumstance.

This means that economic activity and normal, taken-for-granted business activities can be better understood as **'routines'**, taking place within well-understood frameworks of understanding and practice. Routines encompass a whole range of activities from technological to organisational to marketing assumptions. Routines are adopted and stabilised not because of impersonal market forces, but through the collective choices of actors in the economic field which lead to the adoption and stabilisation of ways of thinking and acting within a 'bounded' rationality (Nelson & Winter, 1982).

The significance of this framework is that it points out that our destiny is not determined by completely impersonal market forces but is significantly influenced by individual and collective choices. And those choices include the 'hard' choices of technological systems, but also the 'soft' human choices of what we take to be important, and how we frame and understand the choices available to us.

Link to narrative

The Ginsters, Air Cycle and Southampton narratives all make reference to these theories.

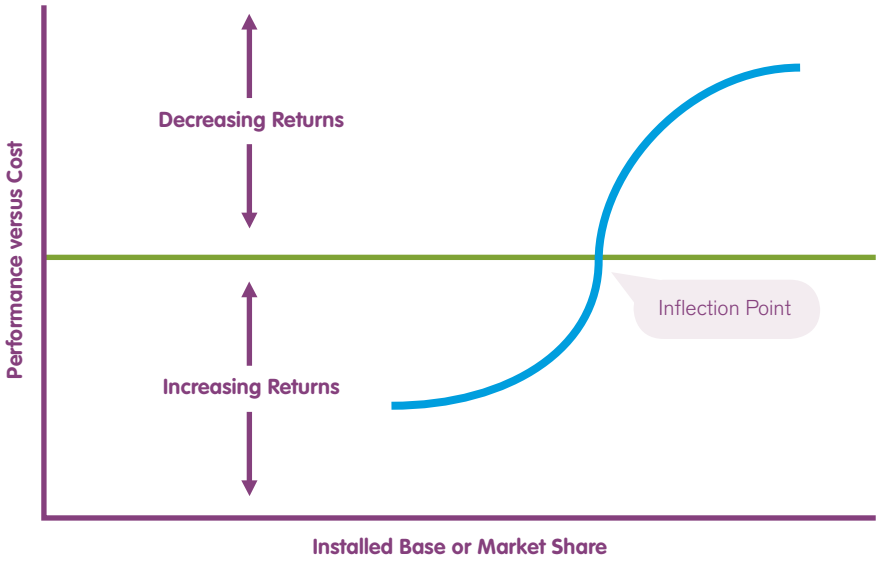
Lock-in

Gregory Unruh's description of carbon lock-in helps explain why, in spite of scientific evidence, international agreements, and national and individual commitments, the shift to much lower carbon industrial practices has yet to gain real momentum.

> An essential insight is that carbon lock-in arises from systemic interactions among technologies and institutions.
> **Unruh, 2000**

> Unruh argues industrial economies are in a state of carbon lock-in to current carbon intensive, fossil fuel-based energy systems, which creates persistent market and policy failures that inhibit the diffusion of carbon-saving technologies, even where these have environmental and economic advantages. He argues that this situation results from a process of technological and institutional co-evolution, driven by path-dependent increasing returns to scale.
> **Foxon, 2003**

In a paper published in 2000, Unruh describes how interactions between technologies and institutions have locked us in to fossil fuel-based energy systems. For example, the technologies and institutions for generating, distributing and using electricity evolved together over time, influencing each others' development and reinforcing each other to become a 'techno-institutional complex' (TIC).



The S-Curve of performance improvement and cost reduction as cumulative volume increases

Unruh (2000) uses the S-curve above to demonstrate how lock-ins occur. An initial period of ferment occurs at the birth of a new technology as radically different product designs compete to meet not just a single user need but a variety of different and contesting needs, such as safety and sport in the development of the bicycle. In due course, one design gains a dominant position by meeting a critical mass of needs. There is then a shift from the performance leaps of the early product stage to incremental process improvement as returns from increasing scale begin to occur. Unruh identifies four types of improvement as the dominant design itself improves:

(a) Increasing scale economies as fixed production costs are spread over greater volumes
(b) Learning economies reduce costs and improve performance as production and market experience generate specialised skills and knowledge
(c) Adaptive expectations as users and producers become confident and increasingly trust performance
(d) Network economies as users, governments, suppliers, regulators and supporting technologies and professions adapt to make use of the new approach, or to support it e.g. as suppliers.

Techno-institutional complexes (TIC) develop through a path-dependent, co-evolutionary process involving positive feedbacks among technological infrastructures and the organisations and institutions that create, diffuse and employ them. Once locked-in, TIC are difficult to displace and can lock-out alternative technologies.
Unruh, 2000

Once a dominant complex of technology and associated institutions has become locked-in, it is typically very difficult to dislodge, even when alternatives demonstrate clear advantages in terms of cost, carbon or both. These four different areas for improvement demonstrate that lock-in is both a technical and a social issue. The latter two, in particular, place the cost benefits from scale well outside the innovating firm. These are picked up by networks at the industry level and well beyond. It is easy to overlook that a) and b) also have social dimensions: for instance economies from scale often result from significant increases in plant size and capital intensity, which involve a range of other organisations including investors, distribution companies and surrounding communities which can quickly become specialised, supplier companies.

Link to narrative

From the perspective of our narratives, Unruh's perspective on lock-in seems rather open and shut: technologies lock in and keep novelty out. However, all the low carbon initiatives described in our narratives are both locked-in and locked-out of sociotechnical regimes.

Most clearly locked-out are Air Cycle – a niche technology locked-out of the existing regime/way of operating the cold chain – and Holsworthy's anaerobic digestion technology, locked-out in the UK context because it was developed with different operating conditions and regulations in mind. But the commercial potential of both rests on the contribution they could make to existing sociotechnical regimes of fast food and intensive agriculture.

In contrast, Thurulie is a clearly novel application of a range of technologies; while at the same time its success rests on the way it fits into the regime of the apparel supply chain. Ginsters' ability to generate energy from waste depends on the waste generated by a regime of factory food production.

…governmental and legal institutions can greatly exacerbate lock-in conditions.
Unruh, 2000

Illustrating Unruh's S-Curve above, this shows why lock-in tends to become stronger over time. As a dominant technology improves through the four types of process a) –d) above, a new technology would need to overcome increasingly stronger financial and social barriers to entry to achieve cost and acceptance parity. New approaches need to access volume quickly to reduce these cost disadvantages – but the cost of learning radically new approaches typically fall heavily outside the innovating firm. Not only will existing large producers be unwilling to invest in approaches that undermine their own core competencies and that threaten their investments, but additionally new contract specifications and inspection regimes need to be written, users need to learn how to use the new approach, suppliers and partners need to change their own production processes (and may risk the good will of dominant design producers in doing so), etc. All this suggests that we must shift our thinking about transitions toward low carbon away from particular technologies toward the complex system of which they are a part.

Link to narrative

The AirCycle narrative shows how a developing niche technology faces enormous barriers in gaining acceptance against the pressures of meeting day to day production demands. It is clearly not only a matter of getting the technology to work economically. The food production companies that might benefit from the new technology are locked in to their present routines by external forces from the supply chain and their own limited response capacity and have no spare capacity to explore how to benefit from new technologies which are not of immediate benefit.

This means that low carbon innovations which do not fundamentally threaten the dominant technical institutional complex, but which rather offer improvements to one aspect of it, face much lower barriers to entry. Additionally they may also typically offer much quicker, though limited, pay-offs in terms of reducing carbon. Perversely, however, while such improvements to the TIC may reduce carbon emissions in the short run in the longer run they actually reinforce it and make it harder for subsequent and more radical transformations to take place. As the TIC becomes more mature, the more such opportunities are recognised and taken up, leading to diminishing opportunities for further improvement.

Link to narrative

We notice, in the context of our narratives, that Unruh's account of lock-in can be read with a strong technological and economic focus. We wish to draw attention to the ways in which social relations, institutional structures, and ways of thinking are also significant factors in creating lock-in. Such taken for granted patterns create what can be called 'regimes of truth' which prevent significant alternatives from being properly considered.

Social shaping of technology

Low carbon technology projects need to take account of how social forces influence particular technologies to emerge as 'dominant'. As human artefacts, both high and low carbon technologies are created by complex, non-linear design and implementation processes, with the technology best suited to the requirements of the most powerful social group/s involved in their creation emerging as the most 'successful' option.

Social scientists offer competing theories of how a particular technology, or rather a complex of technology and associated institutions, becomes locked-in. The Social Construction of Technology (SCOT), developed by Trevor J. Pinch and Wiebe E. Bijker (1984), is particularly influential. This approach stresses that technologies do not become dominant in a linear process which leads to one emerging as the clear favourite, nor, as Foxon (2003) points out, is there a straight line of development between invention, innovation and diffusion. Instead they see the process as a complex one with many feedback loops arising as a technology develops. Variations in design lead to different benefits with different values to different social groups.

Interpretive flexibility
Technology design is an open process that can produce different outcomes depending on the social circumstances of development. …whatever the design that finally results from the process, it could have been different.
Klein and Kleinman, 2002

Technology design is an open process: the same technological artefacts can produce different outcomes in different social circumstances: the artefacts on their own are 'underdetermined'. This provides opportunities for 'interpretative flexibility' so that different aspects of the technology are emphasised and thus become dominant. Pinch and Bijker stress that the neglected approaches are not technological failures but rather alternative (and potentially better) trajectories that were never explored. So why do some approaches die and why do others flourish? Using many historical examples, they examine the social processes of selection around those moments of variation which lead to one approach predominating.

Relevant social groups
Technology development is a process in which multiple groups, each embodying a specific interpretation of an artifact, negotiate over its design, with different social groups seeing and constructing quite different objects. Design ceases not because the artifact works in some objective sense but because the set of relevant social groups accepts that it works for them.
Klein and Kleinman, 2002

Their analytical approach involves identifying the 'relevant social groups' that arise around a technology, which include groups in opposition, and then identifying the values that each group might have with an artefact. For example, as alternative designs for the bicycle were developed, modesty emerged as an issue for women riders, speed for young men and safety for older people, leading to different designs for these different groups. When the air tyre was developed, its benefits could be interpreted in different ways – as offering comfort, speed or safety – and thus met the needs of all three groups, contributing to the emergence of the safety bicycle design we know today. This is an example of a technology closing around a single design.

Closure and stabilisation
Design continues until… conflicts are resolved and the artifact no longer poses a problem to any relevant social group… Somehow a final decision… occurs.
Klein and Kleinman, 2002

Closure and stabilisation, then, is the third component of this perspective. The controversies that arise through different values and interpretations eventually get resolved, so that a technology closes and design stabilises over an extended period (19 years for the safety bicycle). Such closure is not necessarily the 'best' solution from any one particular perspective. This process occurs within a wider social milieu which forms the options available to social shaping.

Link to narrative

Air Cycle is an example of technology that is still being shaped. Different groups still have very different expectations of how the technology can be applied.

This analysis obviously raises important questions relating to power and status – which groups have influence, which come to be recognised and allowed a voice in such technology controversies? The development of technology is shaped by the structure of the social world, with some groups having more power to shape technological choices than others. Some of these groups will have developed quite independently of the technological artefact; new groupings will arise with the emerging technology; some will have greater influence while social barriers will prevent or discourage others from participating. It is also significant that there are very few public spaces in which questions about technological choices can be explored; nor are there clear rules about access and the decision process. These issues are well explored in the context of the adoption of alternative technology by Herman Scheer (2007) who argues that the established network technology, infrastructure, institutional integration and mindset makes a widespread change toward renewable energy highly problematic.

In their synthesis of social approaches to technology, Williams and Edge (1996), stress the importance of meso-level (e.g. firm to firm) interactions alongside micro- (actor network) and macro-level interactions (e.g. at the level of an economy or an industry) in explaining technological change. In their analysis, the process of implementation forms a crucial part of the innovation process. New developments in technology need to be applied to particular needs in particular markets during the implementation process. The feedback processes thereby set up, especially where there is a high level of variation between different actors and locations, provide a strong force for meaningful innovation in the course of the struggle to get the technology to work in useful ways, at the point of application. Feedback processes both ways between wider social context, actors and technologies not only change the technologies but also the landscapes in what they call 'innovative moments' where new technological configurations apply. As this process occurs, sedimentation also takes place, thereby explaining incremental as well as breakthrough changes.

However these theories clearly provides only part of what is needed to understand lock-in. Williams and Edge themselves acknowledge that some aspects of technological determinism remain under addressed by social theorists who are mostly more concerned to explain change processes.

> Innovation is thus seen as a contradictory and uncertain process. It is not just a rational-technical 'problem-solving' process; it also involves 'economic and political' processes in building alliances of interests (amongst, for example, supplier firms, technologists, potential users, funding bodies regulators) with the necessary resources and technical expertise, around certain concepts or visions of as yet unrealised technologies.
> **Williams and Edge, 1996**

> … implementation is an important site of innovation… In this approach, technological development is a spiralling rather than a linear process: crucial innovations take place both at the design and at the implementation stages, and are continually fed back into future rounds of technological change.
> **Williams and Edge, 1996**

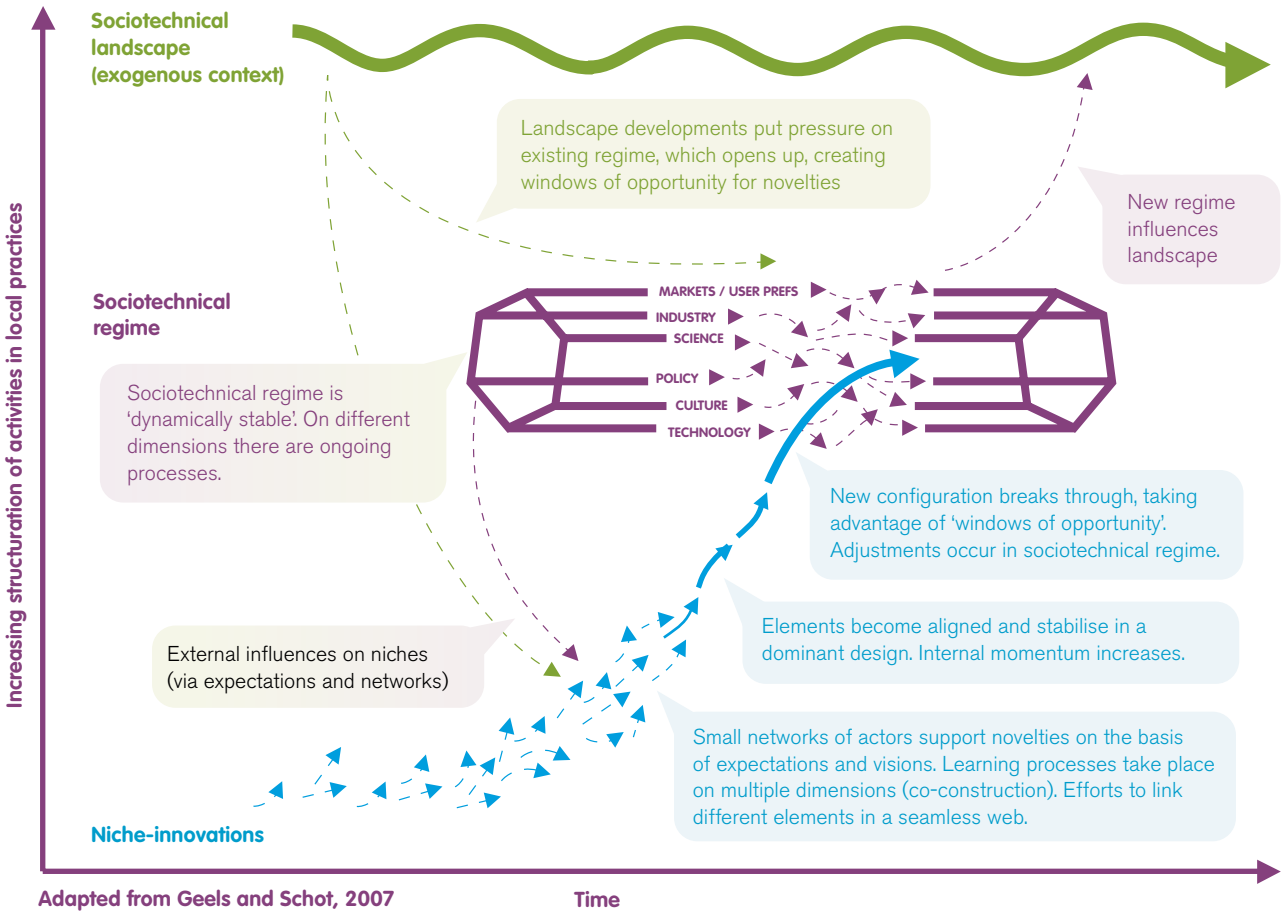
Link to narrative

The Airworx narrative shows how, while society accepts without question that gas and electricity are provided as utilities, there is resistance to the idea that other services such as compressed air can be so provided. In contrast the Southampton narrative shows how, while originally there was resistance to the provision of district energy despite the cost benefits, over time deep rooted patterns of resistance faded and the scheme became accepted

Sociotechnical transition framework

How does change actually occur? Recent theorising shows how we may think about the systemic interconnections of social and technical factors at different levels, and shows some alternative developmental pathways

Frank Geels and his colleagues offer a framework, consistent with Gregory Unruh's approach to lock-in and with the process of social closure, for thinking both about lock-in and about how change does not (and occasionally does) occur from time to time.



Sociotechnical regimes are the relatively enduring and stable pattern of interactions: cognitive routines, regulations and standards, adaptations of lifestyle to technical systems, sunk investments in machines, infrastructures, and institutions and competencies. They take place at the level of organisational fields and create a lock-in to existing patterns.
Adapted from Geels and Schot, 2007

The diagram above shows Geels' framework very clearly. Lock-in to a particular technology primarily occurs within 'sociotechnical regimes' – shown in the middle of the diagram. These are comparable to the Technical Institutional Complex (TIC) of Unruh or the locus of sedimentation of Williams and Edge. These regimes are 'dynamically stable', or even rigid, adapting to disruptions in small ways that make them yet more stable in the longer run. Their stability comes from increasing alignment both within and between rules and regimes (e.g. cognitive rules, regulations and standards), actors and organisations (buyers, suppliers, financiers, etc, which become increasingly adapted to the technical system) and of the sociotechnical artefacts themselves. Once in place the latter are not easily abandoned (e.g. because of sunk costs) and feedback to reinforce other areas as

change becomes ever more expensive to contemplate. Regimes are held in place by many feedbacks – but can also be maintained by direct action – e.g. when a patent to a disruptive technology is acquired and 'retired' by a regime actor.

At the top of the diagram is the sociotechnical landscape, which provides the context for the interactions of actors and is made up of various factors, including commodity prices, major political events, cultural values and environmental problems. While a regime normally evolves to fit a landscape that is slowly changing (over decades and more), sometimes speedier landscape changes stress a regime for a while and open up the possibility of more disruptive change within it. Climate change and energy security questions can be seen as examples of landscape changes that open up potential regime change in affected industries. Equally, changes within regimes can sometimes contribute to the landscape: cars and bicycles led to the road network being established, which is now a significant part of the landscape.

So if people within regimes resist regime change, whether consciously or not, and if the landscape is largely resistant to conscious attempts to change it, where does transformative change most often begin? Geels suggests that the 'niches' shown at the bottom of the diagram are usually the source. These niches can be related directly to the location of the technological struggle described by Williams and Edge.

Both regimes and niches can be seen as organisational fields or communities of interacting groups. While regimes are large and stable, with stable rules for coordinating action, communities around niches are small and unstable, with unstable and developing rules.

Geels' diagram has two-way flows between landscape and regime. And this makes considerable sense: an innovation needs the scale that comes with a regime in order to change the landscape. And while the landscape co-evolves with the regime to a considerable extent, there are times when change is so dominant that the regime is disrupted.

However he shows one-way flows from niche to regime with no flows whatsoever from landscape to niche. Climate change in particular makes these omissions questionable:

- The issue has generated considerable innovation – e.g. in the 'transition towns' movement.
- There is evidence that some 'regime' players are actively seeking innovation – e.g. through the government-funded Carbon Vision project of which this research project is part.

Link to narrative

All the narratives illustrate this theory. For example, the Thurulie narrative shows the interaction between landscape, regime and niche. Landscape changes – in particular changes in Western consumer attitudes toward sustainability – create pressures and opportunities for low carbon production of lingerie. At the same time, capacity to build low carbon facilities have been developed at niche level within the building and architectural professions in general, and in particular among consultants at Moratuwa University. The sociotechnical regime is well developed, but is open to quite radical innovation of the eco-factory because this fits rather than radically disturbs the existing regime configuration: while novel, it still provides high quality and low cost products to an existing marketing process.

Sociotechnical landscape is an environment beyond the direct influence of niche and regime actors (macro-economics, deep cultural patterns, macro-political developments). Changes at this level take place slowly (decades) although have a dynamic quality.
Adapted from Geels and Schot, 2007

Technological niche: the micro-level where radical novelties emerge. These novelties are initially unstable sociotechnical configurations with low performance which act as 'incubation rooms'. Niche-innovations are carried and developed by small networks of dedicated actors, often outsiders or fringe actors.
Adapted from Geels and Schot, 2007

Both niches and regimes have the character of organisational fields (community of interacting groups). For regimes, the communities are large and stable, while for niches they are small and unstable. Both niche and regime communities share certain rules that coordinate action. For regimes these rules are stable and well articulated; for niche innovations, they are unstable and 'in the making'.
Adapted from Geels and Schot, 2007

The multi-level perspective argues that transitions come about through interactions between processes at three levels: a) niche-innovations build up internal momentum, through learning processes, price-performance improvements, and support from powerful groups, b) changes in the landscape level create pressures on the regime and c) destabilisation of the regime creates windows of opportunity for niche-innovations. The alignment of these processes enables the breakthrough of novelties in mainstream markets where they compete with the existing regime.
Adapted from Geels and Schot, 2007

There is an ongoing and very rich programme of research developing and applying this perspective, particularly in Holland, which we cannot review in detail here. However, it is clear that this approach has much to offer to our project, since it provides a way of thinking about stuck technologies in the context of rapid innovation for low carbon futures. We notice how the actual (as opposed to the metaphorical) landscape is largely omitted from this account. Rather, the landscape is articulated as primarily an anthropocentric concept, to the extent that Geels and Schot see 'modern man living in a technotope rather than a biotope. Modern society has characteristics of a "mega-machine"'.

While we accept that our understanding of the landscape will always be socially constructed, we are concerned that the planet itself – which makes possible the sociotechnical landscape – is largely absent from the definition. We do not think that this was accidental but rather an illustration of how the regime itself, and sociological constructs such as 'the market', come to take precedence over the biophysical world in which we live, which is then seen as an 'externality' (e.g. in much economic analysis). As a result we are better at picking up information about the failure of our financial system than we are about the collapse of the ecosystems of which we are part.

Power and critical thinking

In thinking about change – and resistance to change – the concept of power is important, even though the various definitions of different theoretical traditions make it quite difficult to discuss. Critical theory incorporates a body of ideas which seeks to critique society and in so doing bring about change towards greater social justice. It places a particular emphasis on the operation of power, particularly in situations where, because there seems to be a consensus, it is not obvious where power is being exercised.

Cynthia Hardy (1994) identifies four main dimensions or 'faces' of power, building on the influential writing of Steven Lukes (2005.) These are: direct and decision-making power; indirect or non-decision-making power; symbolic power; and the power of the system.

The first face: direct power

Governments, policy makers, managers and other 'authorities' regularly exercise power over others. Such power is usually seen as legitimate, because it stems from a decision-making process whose terms have been agreed by all involved. This is the kind of legislation-supported power used by governments to force polluting industries to clean up their processes, and to arrest direct-action climate change protestors. Although there may be overt conflict in such situations, there is agreement about the right of the decision-maker to resolve the situation. This kind of power is exercised whenever someone is explicitly forced to do something they would not otherwise do.

The second face: indirect power

However, it is often not the case that power is exercised overtly by one individual or group over another. Individuals and groups can also exercise power in more subtle ways, by controlling money, rewards, sanctions, the flow of information, and so on. Those who hold power can manipulate the system in various ways to their advantage, such as by determining what appears on decision-making agendas and what does not, or by setting terms of engagement in a process. This may operate in a top-down fashion so that minority groups struggle to be heard. In some circumstances it can also be a way for countervailing power to be exercised by less powerful people, who might be able to withhold information or their participation in consultation processes. This power of the incumbent can be seen at play in debates about carbon-reduction strategies in infrastructure projects, for instance, where well-established supplier companies are able both to establish barriers to market entry for competitors and find relatively easy access to policy makers.

> It is not necessarily true that people with the greatest needs participate in politics most actively – whoever decides what the game is about also decides who gets in the game.
> **Schattschneider, 1960**

The third face: symbolic power

Lukes, and commentators of the critical theory tradition, see both these views of power as limited, and overly-reliant on the existence of conflict as an indicator that power is being exercised. More importantly, they suggest, power-holders are able to prevent such conflict from arising, through influencing and structuring what citizens want, what they are aware of and what they see as their alternatives. In such situations, people are unable accurately to determine their own interests. Those in positions of power are able to 'manage meaning' (Pettigrew, 1979), using symbols, rituals and myths to create a sense of legitimacy for their actions. A critical approach

> The radical view maintains that people's wants may themselves be a product of a system which works against their interests, and, in such cases, relates the latter to what they would want and prefer, were they able to make that choice.
> **Lukes, 2005**

> Critical theory draws attention… to the objectification of people and nature and thus to various forms of destruction.
> **Alvesson and Deetz, 2005**

asks the question: how is consent and consensus being created and maintained, and in whose interests? In the carbon reduction debate, for instance, we might notice the way advanced capitalist societies promote and sustain a high-consumption way of life, built on an assumption that economic growth is always desirable. Whether that is what people would choose if they understood the full ecological and social implications, is the sort of question this view of power asks.

The fourth face: the power of the system

But not all forms of power are actively mobilised by dominant groups over others. There are also ways in which systems operate more to the advantage of some people than of others through the very act of our participation in them. In this view, power is best seen as a capacity that is distributed throughout a social system, in fluid, subtle and complex ways which are not necessarily predictable or deterministic. Michel Foucault (1977, 1980) is a leading proponent of this perspective. He analyses the ways industrialised societies are pervaded by what he calls 'disciplinary power', overlapping processes exercised unintentionally by social actors which maintain a certain 'normal' life.

Underpinning such regimes are **discourses**, patterned ways of speaking and acting which determine not just what gets decided, nor what it is safe or important to discuss, but what can be discussed without being deemed mad, incomprehensible, or lacking in common sense. This sort of power is not imposed from above, but operates through a self-policing process: Foucault maintains that it is internalised, and becomes part of how we understand who we are. When we see climate change protestors - or climate change deniers – as unrealistic, over-the-top, irrational, we are exercising this sort of normalising power and reinforcing our shared 'regime of truth'. However, Foucault also suggests that such power-systems are dynamic, held together in a pattern of small interacting actions consisting of compliance, resistance and struggle, and hence are open to change. This way of thinking directs attention to ways in which the everyday, taken-for-granted nature of a sociotechnical regime is embedded in, and sustained by, the day to day practices, habits, assumptions, and judgements of individuals in the course of their lives, in relationship with technical infrastructure, social institutions and nature.

Link to narrative

Conducting this project we found the most explicit exercise of power was in the activities of supermarkets and other large retailers. They have direct power over suppliers, setting requirements often in a quite arbitrary manner, driving down costs and delivery times so that suppliers have no opportunity to respond to the low carbon agenda. They also exercise power indirectly in deciding which issues are on and off the agenda: the development of Air Cycle was not on their agenda as they preferred to consider CO_2 as a refrigerant; in contrast, Marks and Spencer's Plan A contributed to the building of the eco-factory at Thurulie.

We can also see that the farming community who initiated the Holsworthy anaerobic digestion facility were relatively powerless in the face of government regulations and the contractors they commissioned, while the company that bought the plant had more useful positional power within waste and energy networks.

Finally, we can see how the overall power of the system (which we might equate loosely with the 'landscape') favours short term over long term and financial measurements over carbon emissions, so preventing the carbon agenda from being fully considered.

Relational practice

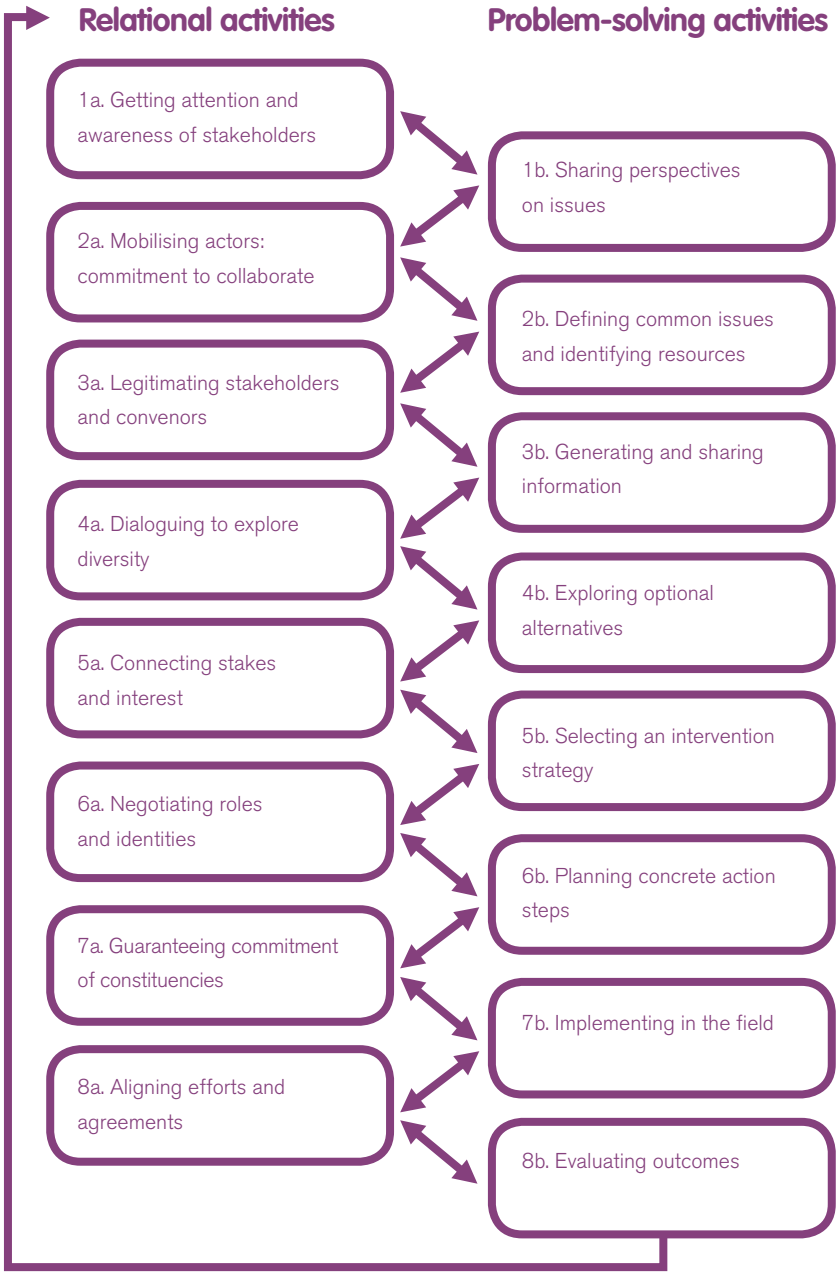
The 'regime of truth' in our current system suggests we can best know about our world objectively, through exploring it as something separate from ourselves. However, theorising about the social world often takes a different view, drawing instead on the idea of social construction (Shotter 1993; Gergen 1999): that the understanding we have of the world we inhabit is a product of the relationship we have with it and with each other. From this perspective, we humans live in the midst of a continuous process of co-creation of our world, a moment to moment process of making our reality, rooted in a relational way of knowing. Relationships are not just what connects humans with humans, but what connects humans with the world we inhabit, both social and physical.

> We must find another relationship to nature besides reification and possession.
> **Haraway, 1999**

Conventionally, the idea of relationship has come to be associated with people forming some sort of emotional connection with each other. But relationship is also a key part of work getting done. The importance of the way people work together is noticeable in the stories presented here: the capacity to create and sustain relationships, often crossing professional and/or organisational boundaries, seems to be a key factor in helping innovation take place.

This is more subtle than notions of 'good relations' or 'effective leadership'. We, and others, find that the people involved have to do a particular kind of work, which we might call 'relational practice'. This includes sharing ownership of a task, communicating openly and directly, finding activities that are mutually rewarding and energizing, and finding ways to learn deeply together. It is expressed in working with stakeholders, mobilizing teams, having dialogues with people who hold different views, getting people to commit to take action, negotiating roles and priorities, and getting efforts aligned. Such actions are task-oriented, yet have qualities of reciprocity (Bouwen and Taillieu, 2004).

Bouwen and Taillieu studied how natural scientists and engineers worked together in projects concerned with natural resource management. They noticed how 'task dimensions' and 'relational dimensions' were interwoven in collaborative problem-solving situations, yet the participants themselves – who were very practised in problem-solving procedures – could not easily see the relational work, even though it was critical to the success of the projects.



Sequences of intertwined relational and problem-solving activities
After Bouwen and Taillieu, (2004)

Other studies of multiparty collaborative projects also highlight the importance of this 'relational space' (Bradbury and Lichtenstein 2000; Bradbury 2009) and existence of strong relationships has been shown to be the most important social factor in predicting environmental behaviour change (Olli, Grendstad et. al., 2001).

So one of the most curious aspects of this relationship-oriented work is the extent to which it takes place without people noticing or valuing it. They may refer to the importance of 'good people management' or the interpersonal skills of members of a project team, but this is not generally rewarded as an organisational asset. Joyce Fletcher (1998; 1999) points out that relational work is present in all effective enterprise, that it is important for task accomplishment, and that it 'gets disappeared' – there is a more or less active process through which it becomes hidden and unacknowledged, and turned from a type of work into just 'being nice' or 'getting on well' with someone.

Fletcher suggests that this 'disappearing dynamic' takes place because of the taken-for-granted assumption that work is conducted in a 'public' world which has become quite separated from the 'private' world of home and family. This is a socially-constructed division, which assigns some facets of human life to the public/work sphere, and some to the private/home sphere. In the public world, there is a dominant discourse of rationality: it is the place where work is conducted, decisions are made, politics is conducted. Thinking is predominantly abstract, instrumental and individual. The private/home world is the place where communion and community are dominant, emotions are acceptable, warmth and caring are encouraged. Current dominant discourse emphasises the public world: it carries more status, and is seen as more important as a source of knowledge, than the private.

The ability to develop relational capacity and competence requires certain strengths: empathy, vulnerability, ability to experience and express emotion, ability to participate in the development of another person, and an expectation that relational interactions will be sites of learning and development for all parties involved. But to recognise and name such attributes means bringing the language and meaning of the private/home sphere into the workplace. To most people in contemporary Western societies this seems like a violation, an inappropriate intrusion of 'private' emotions and activities into a professional setting. The result is that this work is rendered invisible, and reconstructed as something other than work, borrowed from the private sphere, such as a personal characteristic like being friendly or helpful. Fletcher's study found that people engaging in relational work simply did not have strong, valued language to name what they were doing even though it played a significant part in the achievement of tasks in the workplace.

Link to narrative

In the Thurulie story, we see sophisticated relational practice: the way in which the project team were able to embark on a venture in which no-one knew how to do what they were doing involved holding their nerve and collaborative learning. They were also able to stick to their ambition, in the face of practical challenges, because of their strong interpersonal connection and sense of shared mission.

Furthermore, Fletcher draws attention to the gendered nature of this division, so that the public space attributes have become conflated with stereotyped images of masculinity, and the private space ones with stereotypes of femininity, in a way which constrains the behaviour of both men and women. In the public/work sphere, accepted discourse centres on ideas of rationality and development through goal-directed activity. This, she says, is not the only way of conceiving of learning and development: drawing on the work of psychologist Jean Baker Miller, she sketches an alternative, the idea of growth-in-connection, based on connectivity and interdependence. She suggests there is a need for an expanded model of how work is effectively carried out.

Fletcher's critique of the disappearance of relational work, then, draws on the idea discussed in the previous section, that knowledge, language and power are interconnected, and that 'discursive practices', such as the separation of 'public' and 'private' sphere attributes, become taken-for-granted, rooted in common sense, and hence largely invisible.

The 'common sense' of the current sociotechnical regime does not support any innovation towards low carbon that challenges the growth assumptions of the business paradigm (Blühndorn and Welsh, 2007) Exploring alternatives often requires moving against strongly-held, often unspoken, conventions of what is normal,

acceptable and reasonable action to take. There is a fine line between the maverick innovator, whose behaviour is understood and perhaps even admired, and the 'weird' person or group, who have stepped over some unwritten line of acceptable behaviour. Staying on this boundary, and finding ways to stay within expectations of what is reasonable and acceptable, is difficult, detailed work which is strongly relational. If innovators step outside the boundary, they are rejected and their work is irrelevant, but if they don't push at it, nothing significant changes.

Link to narrative

One aspect of doing this relational practice at the boundary of acceptability is the strain it puts on individuals. People get worn out and step back from this edge, but engaging with the 'regime' involves sticking with it. Being a 'champion' is hard work, and much of the work is invisible, even to the person doing it. In the Air Cycle story, the project co-ordinator can be seen in this situation. There is also a danger that such champions turn to each other for support and understanding, and away from engagement with the mainstream. Relational practice is then used within a niche for people to sustain themselves, and the important exchange and learning with those outside the niche is lost.

The significance of relational practice can be seen in most of the narratives in this report. In Air Cycle the persistence of the lead researcher in building networks and holding open communities of practice over long periods of time in order to support niche activities is notable. In the Ginsters narrative we can see how those responsible for waste management built a reputation and a coalition of interest which helped bring the carbon issue more firmly into the organisation's vision. At Thurulie the project manager and others brought relational skill and persistence into building the diverse yet creative team that designed and built the plant.

In contrast the Airworx narrative can be seen as an absence of effective coalition building, so the service initiative is never really supported by an strong supporting coalition. Relational practice will not guarantee success but in most cases it is an essential ingredient for change.

Theoretical reflections

In this section we reflect on our overall experience with Lowcarbonworks and draw together what we see as key learnings and key messages. These insights are drawn from the narratives of change toward low carbon which we have presented, and we offer them with the proviso that such summaries often sound more clear and precise than the narratives actually permit; nonetheless we hope they will be useful to readers. We review what we have experienced as taken for granted assumptions about the transition to low carbon futures, only some of which are useful in supporting the kind of change we think necessary. From this we move to articulate some of the lessons from our action research approach.

1. The way people talk determines what they can see: Discourses matter

As we got involved in the world of people trying to contribute to a low carbon future, we kept stumbling on different and surprisingly separate intellectual and professional communities who talked in very different ways and about very different aspects of the overall problem: their 'discourses' were different. By this we mean they framed their world in different ways for rather different purposes, held different theories which recognised different but necessarily limited aspects of reality, and employed different practices. As a result, they paid attention to and gave value to different 'facts' in the world.

These professional groups include

- Climate scientists of many different disciplines
- Engineers and technologists
- National and local government representatives and policy makers, business people and entrepreneurs
- Economists of various perspectives
- Innovation theorists
- 'Ordinary people': consumers, users, concerned citizens, activists.

These communities used their different discourses to conduct arguments, to research, and to inform their practice. Discourses are often held passionately and with considerable commitment but their meaning may only be shared by peers in the same community. So different discourses can make it hard for different communities to effectively engage with each other – they can get in the way of conversation and action together.

One of the features of the realms of technology, climate change, carbon reduction, innovation and so on, is that they are dominated by a particular configuration of expert knowledge, which is highly professionalised. Members of these communities have spent their whole professional lives acquiring, refining and developing their knowledge, usually with great dedication. This militates against translation from one community to another, and against conversation between 'experts' and 'non-experts'. It is deeply disempowering to 'non experts' who wish to engage in debate and/or action. It reduces those who are not experts to the relatively passive roles of 'consumers' and 'users'.

2. Discourses matter not just theoretically, they matter practically

The discourse is used by a community to perceive and make sense of an issue. It is the way an issue is seen. It is a truism to say that economists see the world in terms of supply and demand, engineers in terms of constructed solutions, policy makers in terms of formal policy statements, action researchers in terms of inquiry processes. But beyond this we want to emphasise that this conceptual framing is largely outside the awareness of the communities themselves. Further, discourses matter in practical terms, because what is seen determines what is done (although the nature of this connection is complex). Discourses, and the theories and practices associated with them, are always located: they are always socially, historically, politically positioned. In this way we may say knowledge is actively constructed by these different sets of players, it is not simply 'discovered' by them in the more neutral terms that we like to think science can accomplish.

The intellectual and social history of our society means that certain discourses are more generally accepted and dominate the shared social discourse. Other discourses are hidden or more actively suppressed and thus disappear. It is evident to us that economic and technological discourses dominate the field of low carbon transition to the exclusion of others.

3. Technology is not the whole story

Technological innovation is important in processes of transition to low carbon, but technology is not the whole story nor is it right at the centre of the story. The technological discourse often dominates the field of low carbon discourses, holding out the promise of particular technological solutions. These are often strongly adopted and lobbied for by politicians and pressure groups, often polarising opinion and creating an unhelpful either/or debate.

4. Economics is not the whole story either

Economic and market structures are important in processes of transition to low carbon, but economics is not the whole story nor is it right at the centre of the story, although they too can dominate the discourse. Prices matter but not to the exclusion of other factors, and in any case, as many of those working in the sustainability field are well aware, current costing models are limited and misleading.

5. Systemic interconnection

Linear models of technological innovation (e.g. from pure research to applied research to development and diffusion) are over-simplified and more systemic models are taking their place. It is generally accepted that the current high carbon social economy is self-reinforcing and self-sustaining. This pattern of dynamic conservatism has been described in various ways including 'lock-in' and as a 'sociotechnical regime'. 'Lock-in' is not just a technological or economic phenomenon: assumptions, worldviews, narratives, institutions, patterns of behaviour are all interconnected in a self-reinforcing system. Researchers have described this process through a variety of interesting models which in many ways are helpful but again are not the whole story.

6. Limitations of modelling

Our perspective suggests that there can be no such thing as 'a model of innovation', and the search for the perfect one is misplaced. There are limits to theorizing and model building. The process is more complex, relational and nuanced than a model can represent. Modelling can serve as an important heuristic, but

a. As we argue above, models will always reflect the modeller's prior theoretical assumptions which are often hidden or taken for granted
b. A model necessarily expresses the discourse of the theoretical community that proposes it
c. Models necessarily are limited in what they can encompass (bounded rationality), and what is omitted may matter very much in practice
d. Once models are adopted people start believing in them, they tend to be concretised and accepted as 'true'; this has been described as the 'fallacy of misplaced concreteness'
e. This can lead to a misplaced sense of certainty and control
f. The creation and reification of abstract models by different expert groups can be disempowering if they are allowed to negate the human potential for creative thinking and acting.

In many ways these comments are obvious but, we would argue, too often overlooked. The nature of discourses, which we outline above, means that inevitably we get taken in by our own narratives which serve our own purposes and as a consequence are prey to oversimplified solutions. The very best we can do is work with an eclectic model and beware the dangers of over-concretisation and bounded rationality.

The misplaced concreteness and certainty is particularly dangerous in the context of climate change since this by definition is presenting humankind with a crisis unlike any previously experienced; one in which existing models and policies are likely to be significantly misleading.

7. How then to act more effectively?

Given this critique of modelling and theorizing and our argument that at the very best models are useful frameworks and at worst dangerously simplified, what can we usefully say about moving more effectively toward a low carbon culture? Because the process of transition is more complex, and full of interdependencies than any model can represent, we need to find ways to help people step into the messiness and complexity of action and adopt disciplines that enable them to create their own action maps – understanding that maps are not the territory. Participants in our studies who were successful in contributing to transition were doing so by being 'in the thick of it' and actively reflecting on what they were doing, building relationships, seizing opportunities and chance events and importantly beginning to question their assumptions and recognise the patterns they were trapped in.

Action research skills, such as the ability to reflect while acting, to facilitate effective conversations, to balance inquiry with advocacy etc, can be important in creating these new and different kinds of conversations. They can create new conversational spaces which allow people to reach across different discipline and practice.

8. The importance of building relationships

Our studies have drawn attention to the way in which everyday discourses and assumptions can make the importance of relationship building invisible. In particular we have been drawn to see the significance of the 'relational' work that goes into

successful transitions. This 'relational practice' includes those behaviours which create, develop and preserve the community of practice in which successful innovation can take place; and attends to its placing in its wider context. Such a community is necessarily complex and diverse, drawing in a wide range of discourses and practices. We have increasingly noticed the amount of time, trust, skill, and attention that goes into the detail of relationship building, the particularity of conversations, the strategic seizing of chance events, and so on.

We have found rare pockets of well developed relational skills where the actors develop individually and collectively highly effective ways of drawing on the diverse skills that are required for the transition. Key people may be experts who over time acquire well developed relational skills; or may be generalists able to work as translators, linking between the discourses of experts and translating into commercial or everyday language. Such people are also able to prize open a space which is not dominated by the taken-for-granted perspectives but allow different people to explore and create possibilities in different sorts of ways.

9. Attention to context

Where there are successful low carbon interventions we see that key actors develop an adequate or 'good enough' understanding of the particular socio-economic context and the relationship of this to different technological options.

10. Learning through good story telling

An important question that arises from this is how we learn from each other and spread 'good practice' from one place to another. For all the reasons we have set out, we don't think models are very good at this (although they are useful in alerting us to different dimensions of the issues). The potential for change is evoked by stories and narratives, particularly stories of what has worked. Thus one of our messages is to create your own stories and narratives of change because these stories really do matter. We are seeking to amplify small stories, to show examples of what is going on, around which different kinds of stories could be built. We learn to notice the patterns that enable innovation to happen more easily through the stories we tell and the stories we hear. Through critical use of story we learn to pay attention to and value these particularities of each situation.

Tools

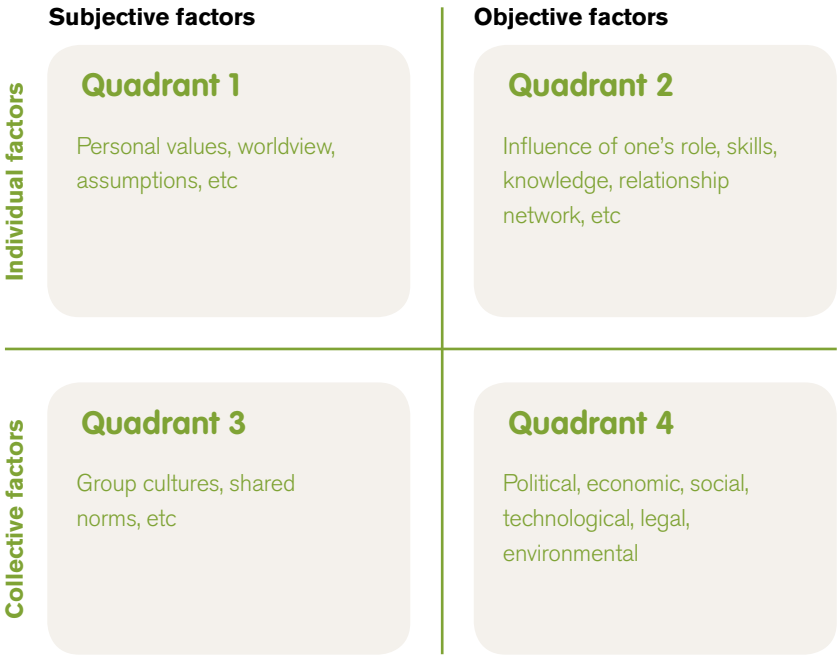
If you want truly to understand something, try to change it.
Kurt Lewin

Complementarities matrix

Any project to create change toward sustainability takes place in a context that offers constraints and enablers, contextual issues that lie outside the direct scope of the activity in question but which have a significant effect on its outcome. Public debate about how to get to a low carbon future often overemphasises technological dimensions at the expense of social and political issues such as governmental and intergovernmental policy, investment cycles, infrastructure, social attitudes and habits. Given the will and the resources, modern society is usually well able to address technological challenges. What is harder is understanding and managing the complex interaction of technological, social and political contextual factors together. Being willing and able to understand, notice and address all these contextual factors is crucial to the success of any low carbon project.

Complementarities theory points to the ways in which contextual issues interact. Change will be facilitated when 'doing more of one thing increases the returns of doing more of another', and 'investing in one variable makes more profitable investing in another, setting off a potentially virtuous circle…'. (Pettigrew et al., 2004). As we have seen, these contextual factors can be described as forming sociotechnical regimes, relatively enduring and stable patterns of interactions between social and technical factors that, once established, 'lock-in' to make significant change profoundly difficult.

David Ballard's adaption of Wilber's integral theory provides a comprehensive way of mapping these contextual issues along two dimensions of individual-collective and subjective-objective (see Wilber, 2000, figure below). Thus change is facilitated when an individual's sense of themselves as being ready and able to take action (Quadrant 1) and having relevant knowledge, skills and capacities (Quadrant 2) occurs alongside cultural impetus toward change (Quadrant 3) and an opportunity in the outside world (Quadrant 4) arising, for example, at the end of an investment cycle when industrial plant must be replaced, or at times of major policy revision.



Complementarities theory suggests that at certain times these contextual factors come together to create a window of opportunity when individuals and groups are more likely to be able to act effectively for change. Quadrant 4 (Q4) presents opportunities for change in the 'real world' – an opportunity in the investment cycle, a change in the market, the arrival of a new technology etc. The response to such an opportunity will depend in part on how it is perceived by individuals within the organisation (e.g. as opportunity or threat) and on their sense of agency, whether they are able to grasp the opportunity (Q1); in part on their knowledge and skills, including their capacity to mobilise people to engage with others (Q2); and in part on the capacity of the organisational culture to support originality and risk taking (Q3). The most highly informed, motivated and capable individuals (Q1 & Q2), even if they have a good idea, will be frustrated if their social context is fragmented and unsupportive (Q3) and if the opportunities in the real world (Q4) are occluded or non-existent. These dimensions are explored in more detail below.

Projects that seriously challenge the sociotechnical regime or aim to build capacity within a niche depend strongly not only on technological competence but also on ability to spot and capitalise on wider opportunities and on fostering relationships and networks for support. There is therefore a systemic interplay between the 'hard' objective world of technology and the 'soft' world of the individual actors making choices. Any theory of change must embrace both aspects.

Thus change for sustainability depends in part on timeliness. It depends on seizing, creating, or adapting opportunities in the external environment, and interpreting them in a way that makes sense in the context of the organisation culture and situation. Such opportunities may be quite brief (we guess that the window for MAS Intimates to respond to Marks and Spencer's call for green manufacturing facilities was probably less than six weeks). So organisations need to develop a capacity over time so they can respond to low carbon opportunities when they arise. Agency – the capacity to take action that will make a difference – is not simply about individual abilities, but occurs at fleeting moments when various individual and collective factors come together.

Quadrant 1: Individual subjective factors

Quadrant 1 maps the inner world of the individuals who might act in response to climate change, and particularly applies to the change agent himself or herself. How they see the world and their role within it, their values and their emotions affect how they view particular situations and how they frame their own potential responses. Four elements are particularly important:

1. Environmental awareness

Individuals need a good understanding of climate change, particularly of the scale, urgency and relevance of its impacts, to cut through complacency and prompt action. An awareness of the complex structure of the issues and the many delays and feedback loops helps them spot opportunities not immediately visible otherwise. And awareness of the limits of what humans can do – that we can't often make changes to natural processes without causing additional problems – prompts them to act with humility, acknowledging that it is possible that 'Nature knows best'.

2. Denial and emotions

Climate change threatens such destruction that many people cannot face thinking about it and live in a state of denial, as described by authors such as Macy and Marshall (Macy & Brown, 1998; Marshall, 2001). On the other hand, strong emotions can have an empowering and motivating impact. Appreciating the emotional work involved in coming to terms with this threat of destruction can help people engage more fully as individuals and with each other.

> I was not only passionate, I was obsessed. When I first started out it was with a very clear sorrow in my heart, and fear for the destruction of the environment.
> **Karl-Henrík Robèrt', Founder of the Natural Step, in Bradbury, 1998**

3. Perceptions of 'agency' – that something can be done

It is clear that many people feel powerless when it comes to responding to serious environmental issues in a personally meaningful way. Such feelings mean people suppress their awareness of the problems on a day-to-day basis. In contrast, people actively working for low carbon solutions often create a sense of agency for themselves by identifying and creating opportunities for action.

4. Ability to conceive and hold a higher purpose or creative vision

Those working positively on climate change often have the capacity to develop and hold a vision of human possibilities that reaches beyond the everyday. On the one hand they regard the present situation with an unflinching gaze, while also holding a vision of creative possibilities, even in the face of challenges and difficulties. Creativity follows from holding that tension and bringing something new into the world. In contrast, progress is easily blocked if the vision collapses and the challenges are met by an inadequate response. This can result in a 'business as usual' mentality which moves us no further forward in the climate challenge.

Quadrant 2: Individual objective factors

Quadrant 2 explores the area of socio-demographics, as well as personal skills, intelligence, knowledge, education and other resources. Two key issues stand out:

1. Demographic factors

First, we need to recognise that there is no overwhelming link between socio-demographic factors such as age, education, social class or gender and one's environmental behaviour.

2. Social and economic position

It seems evident that those whose life circumstances extend beyond day to day survival will be more able to pay attention to the longer term issues of climate change than those nearer the edge. The social and material context of each person determines the arena in which effective action is possible.

3. Understanding of climate change issues

No single person can have a complete understanding of climate science, nor of the intricate interdependencies that hold a sociotechnical regime in place. However, effective action depends on having adequate understanding of the significance of carbon in climate change and of the system qualities that hold the current regime in place – lock-in, potential delays, runaway feedback etc. Individuals who take action – from Cabinet ministers with responsibility for environmental issues to environmental managers in organisations to citizen activists – all tend to develop an understanding which leads to action much faster than those not engaged in the field. Knowledge is compelling: those who know more want to do more.

4. Ability to build and maintain networks and coalitions

Effective actors in this field appear to have significant political and interpersonal competencies although they are not always aware that they do, or have the language to describe them. They are able to operate outside the taken-for-granted boundaries, and have the resources, contacts and skills to do so. They can identify windows of opportunity and then make things happen by working with both formal and informal organisational systems. We explore this in more detail in the earlier **Relational practice** section.

Quadrant 3: Collective subjective factors

Collective subjective factors refer broadly to the accepted understanding of climate change in a society, community or organisation and, more generally, to the capacity of that grouping to support creative and original action. This is explored more fully in the **Organisational responsiveness** section of this report.

It seems evident that an organisational culture with a mindset that is relatively rigid and closed, caught up in its own assumptions, is less likely to be able to respond creatively to the challenges of climate change. Such organisations may experience themselves as relatively powerless within their supply chain, for example. In contrast, organisations that see the challenges of climate change as key contextual issues to which they can respond strategically are more able to be active and creative regarding climate change challenges.

Similarly, some people see strong relationships between the culture of a free society and its ability to innovate (Popper, 1945). And shared beliefs about the impact of human activity on the planet's ecology will impact on the kinds of technology we may collectively choose to adopt.

Quadrant 4: Collective objective factors

Used in corporate strategy processes to map wider contextual changes, these are the PESTLE – political, economic, social, technical, legal and environmental – factors which condition the objective opportunities for low carbon change. The landscape and sociotechnical regime described by Geels and discussed above can be seen as one way of describing the external framework within which an organisation can respond. Among the key factors are:

1. Infrastructure and its replacement

Opportunities for low carbon initiatives take place within an investment cycle and arise when older capital equipment is due for replacement. The replacement process is closely connected to the way technological choices are locked in to sociotechnical regimes (see **Lock-in** section above). If the replacement opportunity coincides with the emergence of a new low carbon technology, a low carbon trajectory is more possible.

2. System delays

Quite apart from the delay inherent in the cycle of capital replacement, there are always delays built into the decision process. For many reasons, low carbon technological choices only become practically available after a significant time delay. It takes time for people in communities and organisations to move ideas into actual action – to learn, build, trial and put things into practice.

3. Legal and regulatory issues

Laws and regulations lock thinking into a particular historical moment and clearly constrain or enable behavioural responses.

4. The limited availability of energy and capital

Systems analyses of the limits to growth (Meadows, et al., 2004) suggest that as environmental challenges accumulate, society is forced to divert scarce resources to deal with emergencies. After a while, the energy and capital required to make the transition to a lower carbon society are no longer available, or may only be available for a limited time. Similarly at an organisational level, the challenges of developing low carbon strategies require managerial and technical attention as well as financial capital, which will be more available in successful companies.

Edgar H. Schein regards the heart of an organisation's culture as 'a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration. That has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to these problems'. He divides organisation culture into three levels:

- Artifacts: surface aspects of culture such as dress, buildings and behaviour which are easy to see but sometimes hard to understand
- Espoused values: explicit goals, philosophies, strategies, values etc
- Basic assumptions and values: the essence of a culture, difficult to see because they are often held at an unconscious level, yet often the key to understanding why things happen as they do.

Schein, 2004

The renewable energy expert Hermann Scheer writes of mental hurdles that pervade discussion and cannot withstand closer scrutiny. They are based on fundamental assumptions that are regarded as established facts and therefore require no additional justification. These questionable assumptions are shared by society's functional elites, who practically close ranks around them; they are taken for granted as if they were predetermined, rock solid facts.

Adapted from Scheer, 2007

Delays in market and technology responses can be much longer than economic theories or mental models expect.

Meadows, Randers, & Dennis, 2004

Illustrations of complementarities from the narratives

Holsworthy

From the Holsworthy narrative, it becomes clear that there were complementary contextual factors operating in all four quadrants which together contributed to this particular change initiative occurring at this particular time. Enabling factors allowed this project to get off the ground and the plant to be built. But blocking factors served eventually to make the project unsustainable and forced the Holsworthy group to sell. The new owners were able to overturn these blocking factors and make a commercial success of the plant, because of the particular skills that they possessed in Q2 (individual skills and knowledge) which were different to the skills possessed by the Holsworthy team, and more complementary to the factors present in Q4 (political, economic, social, technological, legal, environmental).

Although the catalyst for change can arise in any of the quadrants, or in several of them at the same time, at Holsworthy the impetus started in Q4. This was then complemented by the personal qualities and values of the people involved (Q1) and the supportive qualities of local networks (Q3). Finally, the openness and initiative of the project leaders (Q2) enabled these subjective factors to be acted upon in ways which allowed real change to take place. Thus a sequence of change can be seen through the quadrants from 4 to 1 to 3 to 2. This does not suggest that change is in any sense a linear process, but rather illustrates how change initiated in one quadrant can unlock changes in the other three quadrants, provided the propensity for change is present in each of them. If, however, there are 'blocking' factors present in any of the quadrants, this can slow down the process of change, or, at worst, block it altogether.

	Subjective factors	Objective factors
Individual factors	**Quadrant 1** **Enabling** • Project leaders open to new ideas • Seizing opportunities when they arose • Willing to step outside professional boundaries • Passionate and determined to overcome obstacles	**Quadrant 2** **Enabling** • Good local knowledge • Ability to build coalitions and local partnerships • Sound business acumen **Blocking** • Recently acquired technical knowledge • Poor knowledge of electricity regime • Weak industry power
Collective factors	**Quadrant 3** **Enabling** • Supportive farmers' network • Strong local community • Team willing to learn collectively	**Quadrant 4** **Enabling** • BSE crisis in farming industry • Waste legislation tightening • Waste disposal costs rising • Emerging waste-to-energy technologies in Europe **Blocking** • Lack of UK investment capital

Thurulie

The complementarities matrix for Thurulie demonstrates how a fast response is possible when the four quadrants come together strongly. The enabling external factors are of great importance: a significant opportunity arises through Marks and Spencer's Plan A, which is supported by the strategic ambitions and placing of the company and its history of quality initiatives, and also by the requirements of the Sri Lankan national economy. The individual abilities of the project leader – both his capacity and willingness to take the initiative (Q1) and his understanding of the relationship between climate and business strategy (Q2) – are clearly important. But his work is significantly helped by the capacities of other members of MAS and the Moratuwa University consultants, who are excited by the opportunity (Q1) to get involved in the project and together have the necessary skills and knowledge (Q2). All this is supported and indeed amplified by the culture of MAS (Q3) which encourages risk taking, and by the quality of team work which is shared by all those involved in the project.

	Subjective factors	**Objective factors**
Individual factors	**Quadrant 1** • Key people in MAS are highly motivated to take initiatives to place the company in a strong position • Key people at MAS and Moratuwa University are open to risk-taking experimentation • The project leader and others hold a vision of what is possible	**Quadrant 2** • There is a strong understanding of the links between carbon, climate change, business strategy and the needs of the national economy • The project leader has developed relational abilities enabling him to provide leadership across different aspects of the project • Team members collectively have the technical understanding and skills required
Collective factors	**Quadrant 3** • The 'go beyond' culture of MAS encourages and supports initiative and risk taking • Key actors have strong colleagueship built over many years • A culture of trust and creative dialogue engages all members of the team	**Quadrant 4** • Marks and Spencer's Plan A initiative opens an opportunity in the supply chain • The economic position of Sri Lanka makes it imperative to move up the value chain • MAS is a major company with significant influence in the country • A small country with a highly educated elite makes for fast networking • Market and legal conditions in Sri Lanka are flexible

The complementarities matrix was also used in the Airworx project. Please see the narrative for further details.

Organisational responsiveness

What enables one organisation to tackle climate change more effectively than another? How does an organisation know when it's stalled on the climate change agenda? And what does an organisation have to do next in order to progress? The PACT (Performance Acceleration for Climate Tool) framework (Alexander Ballard Ltd, 2008) aims to help people identify what level of climate responsiveness their organisations need to attain, to pinpoint where they currently stand in relation to this goal and to map out the practical actions that can help them to move forward quickly.

Organisations progress through a number of stages or 'levels' as they respond to climate change. As their competency grows, their responses to the issue become more sophisticated and more effective. Put simply, an organisation that responds to climate change only by changing the light bulbs is demonstrating a lower level response than one that can change the design of its products or services to be more resilient to climate impacts and/or reduce carbon emissions big-time. In the jargon, the second organisation is demonstrating higher 'adaptive capacity'. The PACT framework builds on other work (significantly on Dunphy, Griffiths, & Benn, 2003) to clarify what each of these levels looks like.

Six levels of response

Organisations can improve their response to climate change in six predictable stages, becoming able to handle issues of increasing complexity as they understand the issue better and build their own capacity.

Response level one: Non-responsive

Senior managers see climate change as threatening and would prefer not to engage with it. There will be reluctant action, if any. No resources will be allocated. Most businesses have moved beyond this stage.

Response level two: Compliant

Managers will respond to pressure from legislation or customers but won't be proactive. There is little understanding of climate change issues and how they apply to the organisation's activities, and actions risk being a tick-box exercise. Many organisations are responding to changing needs of major stakeholders, so avoiding costly emergency actions to comply under duress.

Response level three: Efficient management

Managers recognise that climate change needs to be managed systematically, rather than occasionally. There will be measurement systems and targets, ISO 14001, carbon management, etc. Climate change is usually delegated to someone lower down the organisation; senior managers may think they've cracked it. Work at this level does provide a foundation for later progress. But relatively few, even at a senior level, yet grasp the scale of the climate change challenge, especially for adaptation. Many organisations are beginning work at this stage.

Work at levels one to three represents business-as-usual management. But climate change is certainly not a business-as-usual issue. We know for sure that the future will not be like the past: procedures and ways of working that were good enough then

will not be good enough in the future. This is a strategic issue, challenging the basics of organisational functioning. It needs the strategic perspective of the boardroom to be involved, building on and interacting with the strong operational grip of the agenda that begins to be developed at level three.

Relatively few organisations (in either public or private sector) have yet made the transition to the boardroom or senior officer or elected member teams that is facilitated at level four and which is required for effectiveness at levels five and six.

Response level four: Breakthrough projects

Top managers begin to set targets for significant performance breakthroughs, reaching beyond the status quo and requiring a search for altogether new approaches. These projects allow participants to explore issues in depth, building a base of understanding of issues and options from which leaders can responsibly set the organisation's future direction. Focusing on areas where win-wins with the organisation's other priorities are possible, such projects potentially offers multiple benefits e.g. costs, revenues, relations with stakeholders and reputation. Recognising and using response level four represents the current challenge for many programmes.

Response level five: Strategic resilience

Top management teams recognise that climate change is of significant strategic importance. They are active on the issue as a key part of strategic management, ensuring every aspect of the organisation (capital, plant, facilities, services) and its wider systems are resilient to climate impacts and an energy-constrained future. Serious climate change responses need an ability to work at this level, which is still rare.

Response level six: The champion organisation

At this level, still very rare, the organisation's focus is on significantly influencing the political, social, legal and technological environments in which it operates in order to promote sustainability, rather than just respond to a changing climate. Very few organisations yet work consistently at this level.

While increasing capacity can be shown to significantly help wider social responses to climate change, not all organisations have an equally compelling business case to reach the higher response levels. However organisations that take big money decisions that are semi-irreversible over a 20+ year timescale, those with a strategic role, or which hold significant assets, usually have a business need to activate response level five, alone or with others. For most, this remains quite a challenge. For many it is not even recognised as a challenge.

Nine developmental pathways

How does change happen? More is needed than just deciding to work from a higher response level and hoping that it will happen! The PACT research suggests that each level needs a sufficiently strong base in the response levels below: capacity needs to develop upwards step by step. To sustain movement from one response level to another requires parallel progress along nine complementary developmental 'pathways' – organisational capacities which research shows to be necessary to improvement. These – and the ways in which they interact – are summarised briefly below:

a) Awareness

The capacity to grasp what climate change means for society, for the organisation and its mission, and for particular areas of responsibility, now and into the future.

b) Agency
The capacity to spot, prioritise and develop opportunities for meaningful and timely action on climate change.

c) Leadership
The capacity of a formal leadership team to develop a strategic vision and to engage with, support, direct and legitimise its implementation.

d) Agents of change
The capacity to identify, empower and support individuals or groups of change agents to become an effective 'ecosystem' of champions.

e) Working together
The capacity to involve, respect the needs of, learn from, and act in collaborative partnerships with internal and external groups.

f) Learning
The capacity to identify and learn from the results of activities and other developments and to use learning to improve procedures, strategies and mission.

g) Managing operations
The capacity to get to grips with climate change in a systematic way to ensure that intentions and policies turn into action.

h) Programme scope and coherence
The capacity to develop an overall programme of action suited to the scope of what the organisation is trying to achieve.

i) Expertise
The capacity to recognise, access and deploy the necessary skills, understanding and technical and change expertise to make the biggest difference.

Each pathway needs to be activated quite differently at each response level. It is not a case of doing more of the same thing but of doing things differently. There is often a double change agenda: both reinforcing the current position and moving ahead to the next response level.

How organisational behaviour changes at key response levels

It is worth exploring how the different levels of organisational response map onto the sociotechnical transition framework of niche, regime and landscape change. In terms of the transitions needed to respond to climate change, the critical differentiation is between response levels three (which might be seen as optimisation within the regime), four (niche experimentation) and five (regime – and to some extent landscape – reconfiguration). What are the critical differences?

Response level 3: Efficient management
The organisation optimises within the 'regime', becoming active in its own right, but does not challenge it in any significant way. Since most 'regimes' have been constructed around significant and cheap energy use, with no thought of radically changing climatic conditions, this means that improvement inevitably levels off in due course.

Awareness needs to be sufficient to recognise climate change as an issue that requires proper management attention, and is typically consistent with that of an issue such as employee safety. People understand the basic mechanisms but rarely think

deeply about a significantly changing future. **Agency** is seen in terms of opportunities to lower costs, to avoid bad publicity, and to participate profitably in new markets. **Leadership** focuses on managing an organisational programme: budgets, reviews, policies, the occasional speech, little hands-on involvement.

Agents of change are seen as business modifiers so they are selected for their technical competence and organisational role rather than for their change skills. Approaches to **working together** are primarily those of strong communication: listening to what people expect, sharing and modifying plans. **Learning processes** are those supported by carbon management and similar programmes: making sense of outcomes using 'quality circle' approaches to improve practice.

Managing operations emphasises continuous improvement of project plans, year on year improvement targets, measurement, procedures, allocation of resources, and corrective action systems. Review processes ensure that **programme scope and coherence** changes to address issues that block progress. However those issues that lie outside the organisation's sphere of control, or which question the core business model or taken-for-granted assumptions, tend not to make it onto the list. Requirements for **expertise** in standard operations are increasingly understood: people learn where it is located and how to access it when necessary.

Link to narrative

Where was CompAir on organisational responsiveness? First of all, Airworx was a pocket of activity within the wider CompAir offering which was responding to climate issues indirectly though energy efficiency ie: more efficient compressors. Airworx as a radically different service offer within the UK industry regime could have significantly contributed to CO_2 reductions and the climate disruption debate in its sector. We believe the CompAir board provided insufficient strategic support for this potential contribution, and perhaps understandably were more concerned with the continued existence and sale of the company. The unstated task of reshaping the sociotechnical regime was tacitly delegated to the sales team. This highlights CompAir's 'business-as-usual' response to climate issues, working at Response level two: Compliant and Response level three: Efficient management levels. Had Airworx been seeded, supported and promoted by senior management at CompAir, it could have been a Response level four 'breakthrough project', but the lack of high level support and initiative precluded this.

In terms of the nine pathways to change, several were in place in CompAir/ Airworx. For example, there were signs of awareness, pockets of agency and some leadership and change agency. Expertise in how to set up an Airworx service agreement was held in isolation by a few people, some of whom were outside of the organisation. But working together, systematic learning and operational management and programme coherence were lacking at this time.

Link to narrative

The Ginsters narrative demonstrates a progression over time through the response levels. Organisational attention was drawn to the need for compliance with new pollution regulations (Response level two: Compliant) and as a consequence the company began to build capacity to respond to environmental issues. In the early days this team was mainly engaged in responding to legal requirements but some effort was available to develop more efficient waste processes. As a result, the links between the legal requirements and organisational efficiency became visible, and the organisation moved into a more intentional phase of eco-efficiency, increasingly supported by expertise and investment (Response level three: Efficient management).

Much of the Ginsters narrative points to the long term effort needed to build this capacity and the links between eco-efficiency and business strategy, with both successes and failures along the way. Latest developments in the company, which we describe in the narrative as 'moving ahead of the curve' with a state of the art waste to energy technology, suggest that the organisation might be moving toward Response level four: Breakthrough projects.

Response level four: Breakthrough projects

As the organisation begins to recognise that it needs bigger transformations than the regime can offer, it begins to seek opportunities to move far beyond 'business as usual' improvement. As it does so, it learns much more about the issue, about what is possible and about the regime and landscape constraints that block progress. However it is not yet ready to tackle these constraints in a systematic way.

Awareness has developed to the point where climate change is seen as a growing strategic threat that fundamentally challenges business as usual over a decade or more. Since strategic responses are rarely clear, the search for **agency** looks to identify and exploit opportunities for significant breakthroughs that make sense in terms of other strategic agendas. **Leadership** does not feel comfortable risking the organisation on issues not well understood. They lead by learning, setting ambitious targets for key projects, staying close to what happens on the ground and putting trusted high ability people in direct charge of them.

As radically new approaches are sought, **agents of change** are increasingly valued for their change skills as much as for their technical expertise. Breakthrough activity normally requires **working together** in creative partnerships over extended periods of at least six months. The emphasis shifts to identifying where there are shared agendas and to building the trust necessary to work creatively together. It is not enough for **learning** to focus on doing things better: more radical change is needed. So learning becomes more reflective, capable of recognising where cultures and mindsets are blocking change and refocusing as necessary.

The **management of operations** needs to be reconceived substantially in the hunt for breakthroughs. It is not enough to deliver to a predefined project plan, since breakthroughs cannot (by definition) be identified at the beginning of the process. Budgets, project partners, even the targets themselves, might be expected to change significantly. The emphasis in measurement shifts to best practice everywhere, not just in a region, country or industry. Controls emphasise responsible innovation, defining the boundaries of the project and managing risks to the core business. **Programme scope and coherence** shifts to address issues outside the organisational boundary or which challenge custom and practice. However there is not yet a process for systematically harnessing the learning from breakthrough activity. Unusual **expertise** is needed and the organisation looks for it far outside its own boundaries.

Link to narrative

The relationship between MAS Intimates in Sri Lanka and Marks and Spencer demonstrates the development of sophisticated levels of response to the carbon challenge. MAS Intimates have a history of leadership in their country particularly around employment practices: the organisation's culture has for a while been beyond Response level two: Compliant as it has sought to differentiate itself from competitors. The response to the carbon challenge has been relatively new, but these historical factors enabled the company to be ready to invest in the new iconic factory which clearly represents Response level four: Breakthrough projects.

While we have not engaged with Marks and Spencer apart from on the Thurulie project, public documentation suggests that the company's Plan A is intended to be a strategic business response to the sustainability challenge. It is tailored to its unique position on the UK high street and its customer base and can be similarly seen as Response level four: Breakthrough project.

Further, we can see that the relationship between the two companies creates new possibilities for transparency in the apparel supply chain which have some similarity to initiatives such as the Forest Stewardship Council.

Response level five: Strategic resilience

Most industry regimes are predicated upon easy energy availability and reasonably predictable climatic conditions. This means that investments over strategic timescales (25 or more years) will be vulnerable unless the regime also changes. At this point, work inevitably moves beyond the organisation's boundary into the wider system of which it is part. Relating this to the sociotechnical transition framework, the work inevitably moves towards 'regime reconfiguration'.

Awareness needs to extend over the life of the most significant decisions – upwards of 25 years and often (for major infrastructure decisions) towards the end of the century. This moves deeply into uncertain climate-affected scenarios, some of which are very challenging; awareness at this level is not an easy burden to carry. **Agency** focuses on sustaining the organisation's primary purpose in a radically changing environment. Opportunities to affect strategic risk in a significant way come and go very quickly: agency is very much about recognising and seizing the moments when change is possible rather than where 'lock-in' occurs. This opens up the regime to make future change easier. **Leadership** must connect people with the organisation's higher purpose in a way that they find meaningful. Leaders need to clearly relate climate resilience to core strategy, to set up strong governance processes for major decisions and to act as effective top level change agents within the wider regime.

Regarding **agents of change**, there are processes to develop an 'ecosystem of champions' so that future changes can be supported at various levels. Since regime change is essential, this ecosystem needs to go well beyond organisational boundaries. The emphasis on **working together** becomes building networks for change with strong alignment of interest across the regime. Since organisations' capacities differ significantly, realistic assessment of their current status is needed so that their role can be configured at a level that they can handle. **Learning processes** shift to knowledge creation and management across a much wider group of actors, ensuring that learning about barriers to change is captured and directed to the place in the wider system where it can be acted upon.

The emphasis on **managing operations** shifts to developing approaches that are resilient under a range of different scenarios. This requires attention to be paid to the wider rules and regulations of the regime itself, ensuring that these are aligned with the

resilience agenda. To do this, building on learning, programme scope and coherence needs to be kept under continual review, moving closer to real time programme redefinition as new projects, and new types of project, are formulated in the light of learning. In a complex programme of activity, it is necessary to create systems of expertise that allow the 'unknown unknowns' to be systematically recognised and appropriate expertise brought to bear on them.

Link to narrative

Both MAS and Marks and Spencer might also be seen taking early steps toward Response level 5: Strategic resilience, not only in linking their business strategy to the long term challenge of climate change, but in action to condition their business environment. Marks and Spencer does this in several ways, including the move to influence the supply chain through encouraging the building of eco-factories. MAS does this by building an iconic factory which will influence apparel manufacture in tropical countries, and by bringing about changes in the energy market regulations in Sri Lanka to encourage the production and marketing of renewable energy.

Recommendations

The possibility, indeed the inevitability, of human choice, lies at the core of the climate change issue.
Rayner and Malone, 1998

Ten ingredients for low carbon change

Progress towards a low carbon future takes place in a social-technical-economic 'landscape' in which opportunities for change arise but briefly. The most fruitful opportunities occur when diverse factors such as economic opportunities, technological options, cultural and organisational conditions, individual skills and motivations complement each other. In such instances, doing more of one thing increases the returns of doing more of another, and sets off a potentially virtuous circle.

Effective action for sustainability depends on seizing, or creating, such opportunities. Our narratives have yielded some common ingredients enabling effective action, which we present not as a rigid recipe, but as a way to 'do the best you can with what you have.'

1. Diverse coalition

There is a coalition of people crossing professional and/or organisational boundaries which possesses relevant skills, knowledge and political positioning and whose clear focus is unconstrained by normal functional boundaries. The members of this team develop strong trusting relationships with each other.

2. Systemic understanding and timeliness

The group works to develop an understanding, at least implicitly, of the broadest systemic context of the work, the technological choices, the economic opportunities and constraints, the cultural enablers, and so on. Within this context they are able to identify a clear opportunity and seize the moment for initiating change.

3. Translator go-between

At least one person is able and willing to act as translator and intermediary between different expert-knowledge groups – technical, scientific, business, activist etc. This is a really important role, and may be filled by more than one person.

4. Wide vision

People within the coalition are able to act strategically, with a clear sense of purpose and with an eye on the bigger picture. They understand that different people bring different perspectives and value that. They spot opportunities and make good use of chance and serendipity; they find people to help make sense of things and give support outside the immediate professional environment.

5. Agency

Individually and collectively, this group is able to see opportunities in which to exercise 'agency', to be proactive. Together, they are willing to take risks, to experiment. They are able to live with some uncertainty and ambiguity.

6. Enabling culture

Change agents are operating inside an organisational culture that in some way enables proactivity, or at least does not squash it. This may include creating a protected space and building alliances with powerful individuals who can protect experiments.

7. Daring to not know

Individuals know they do not have all the answers, that they are not experts following a clearly laid down path. In consequence, they approach their work together in a spirit of collaborative learning, developing an active culture of discussion.

8. External networking

As part of this, they link to and consciously build wider networks outside their immediate organisation.

9. Amplifying feedback

The team are in an environment that in some way rewards and amplifies the innovation (there are positive feedback loops) so that room for manoeuvre gets larger as the project progresses. As this happens, others are attracted into it so the project develops a positive reputation or story which is told outside the immediate circle.

10. Tenacity

Team members are prepared and able to exert influence on the constraints that they encounter. They are willing where necessary to seek to change or challenge rules, standards and procedures that are potential barriers. They show tenacity in this.

> We were all explorers. I think one of the key successes of this project is that no-one came to the party from the position of, 'I'm an expert on this'. But everyone came with some portion of, 'I think I can contribute to this', and then we found our way together.
>
> **MAS team member**

Key issues for policy makers and research funders

Low carbon policy and funding prescriptions tend to focus on technologies and economics. Our research highlights that this limited focus is not enough to achieve carbon savings in organisational settings. Successful change only happens when openings arise in the wider sociotechnical system and organisations have the capacity to both spot and creatively respond to those openings.

Policy initiatives and research funding need to be placed within this wider systemic understanding. We suggest the following as important areas for action:

1. Understand the systemic nature of change

Policy makers need a theory of how change happens which matches the challenge and the complexity of the issues. Discredited notions that technological change can be simply 'rolled out' in a linear fashion are still widespread. But we have shown that change is emergent and unpredictable, and that one model doesn't fit all. Change depends on how a range of complementary factors are brought together in the specific situation, particularly the interchange between the opportunities that arise and the capacity of the organisation to respond.

2. Focus interventions on system opportunities

Understanding the relationship between 'landscape', 'regime' and 'niche' is essential, so that interventions can be appropriately tailored to the opportunity available.

a. Use legitimate framing power to condition the landscape

Policy initiatives such as the Climate Change Act and the Merton Rule, funding opportunities and other initiatives all help to create a climate of opinion in which low carbon projects are more likely to flourish. Developing ways of spreading accounts of good practice will increase the groundswell of opinion that low carbon changes are possible, practical and beneficial.

b. Seek and create opportunities in the regime

Opportunities for change arise when locked-in patterns become unstable, and interventions then can have a disproportionate impact. Timeliness is all-important. Significant change will often be a reconfiguration of existing practices and technologies rather than startling new technologies.

c. Support the flourishing of emergent niches

Niches are the kindergarten where emerging low carbon technologies and other practices develop. Niches need to be nurtured as such, properly funded and protected and not exposed too early to the ruthlessness of the existing regime which will crush them.

3. Support and foster organisational readiness

If organisations aren't flexible, creative and open, they can't make the most of the windows of opportunity that do arise. Political action is needed both to encourage those that have yet to respond to the challenges, and to recognise those that are truly innovative.

a. Develop programmes specifically to encourage more reluctant business and public service organisations to respond actively to low carbon opportunities along the lines suggested in our ten ingredients.

b. Actively engage with business and public organisations already in the later stages of organisational responsiveness through awards, recognition, tax advantages etc. Initiate a Queens Award for low carbon practice.

4. Actively build coalitions and dialogue

Creating more links between policy, funding and the messy world of implementation will generate learning for everyone involved.

a. Pay close attention to the relational aspects of low carbon change work. Put resources into cross-boundary dialogue between policy makers, researchers, business, local authorities and citizens. Value, resource and support this properly, rather than paying lip service to 'partnership' with the same old interest groups.

b. Make sure funded research projects are explicitly required to develop relationship-building capacity. Too often this important relational work is underfunded and overlooked.

Glossaries and references

General glossary

Action research encourages people – including non-academics – to develop a rigorously inquiring approach to their own life and work. It integrates theory and practice, action and reflection, so that the knowledge gained in the inquiry is directly relevant to the issues being studied and the people doing the studying. Action research is participative, aiming for increased collaboration between all those involved in the inquiry project.

Bounded rationality is a view that choices are not made with full information and full rational calculation. Decision makers are 'bounded' by the limits of their cognitive processes and the circumstances of their environment.

Complementarity refers to the idea that things tend to reinforce each other in cycles which can help or hinder change. When enabling factors stack up together and reinforce each other, change is more likely to happen.

Critical theory, rather than attempt to simply describe society, seeks to critique it and in so doing bring about change towards greater social justice.

Discourse is a term within the broad approach of **social construction** which points to the ways in which the form of our language determines much of the way we view reality. Misunderstanding and conflict can arise when different groups employ incompatible discourses to address the same issue.

Evolutionary economics describes the unleashing of a process of continuous competitive technological and institutional innovation. It focuses on the processes of learning and the bounded rationality of actors that transform the economy from within.

Feedback is a term from systems thinking which describes cause-and-effect relationships which close back on themselves. Positive feedback loops create self-reinforcing, even runaway change; negative feedback loops in contrast are stabilizing. Most systems are best understood as a combination of positive and negative feedback loops.

Landscape is a term we borrow from the **sociotechnical transition framework** to refer to the broad economic and cultural environment within which people attempt to create change. The landscape is not accessible to direct influence and usually changes slowly over time. We have included the state of the planet's ecology as an important aspect of landscape.

Learning history is an account of change that gets into the human story of what happened and the experiences of those involved. It presents perspectives on a situation rather than synthesizing several accounts into one dominant researched 'truth'. Encouraging a pause in action to reflect on what's happened, the goal of a learning history is to help those immediately involved and other interested parties learn from innovative changes.

Lock-in is a term we borrow from the sociotechnical transition framework to refer to the way that **sociotechnical** systems become self re-enforcing to the exclusion of even preferable alternatives. This is a form of negative **feedback** in that existing systems have built-in advantages which make it hard for alternatives to compete.

Narrative is an account that expresses the character, detail and drama of human experience. Narratives show the messiness and complexity of events as they unfold to form a unique situation, and highlight how those engaged are doing their best with necessarily limited understanding.

Niche is a term we borrow from the **multi-level perspective** to refer to situations in which innovation is created. A niche is properly seen as **sociotechnical** in that technology and social relations are tightly connected, but in a way that is less well organised and self sustaining than the sociotechnical **regime**.

Path dependence explains how the possibilities of any given circumstance are limited by the decisions and actions already taken.

Realist, or Positivist, worldview asserts that there are real objects in the world that can be directly known and described. Language and theory directly mirror the way things actually are, rather than being **discourses** which shape the way we see reality.

Regime is a term we borrow from the **multi-level perspective** to describe the 'business as usual' way of doing things. Regimes are highly stable and enduring because the patterns of technology, economics and social structure (the **sociotechnical** interactions) all reinforce each other.

Relational practice is the work that goes into enabling people to work productively together: building coalitions, developing shared frameworks of understanding, managing differences and so on. We hold strongly to the view that much of this work is rarely seen and valued.

Social shaping of technology (sometimes social construction of technology) describes the way different social groups interpret technological innovations to suit their own interests, which in turn contributes to how new technologies develop.

Social construction, in contrast to **realist** or positivist worldviews, argues that the understanding we have of the world we inhabit is a product of the relationship we have with it and with each other. So as we live our lives, we continuously co-create our world primarily through our use of language and **discourse**.

Sociotechnical is used here to point to the way in which **technology** is intimately linked with the structure of society, with its economics, politics, social relations, worldviews and so on. Technological change is closely linked with changes in society. Sociotechnical systems are maintained by **feedback** loops that can create very stable patterns; but can equally change quickly if the information flows change.

Sociotechnical transition framework refers to the idea that change happens when developments at the levels of '**landscape**', 'sociotechnical **regime**' and 'sociotechnical **niche**' are multiply aligned.

Technology is used in this report to refer not simply to machines and techniques but to whole systems of production, service, organisation etc. We use it almost exclusively as part of the hybrid **sociotechnical** to emphasise the close interlocking of society with the things it creates and uses.

Technical glossary

In the course of this project we engaged with initiatives drawing on the following technologies:

Absorptive cooling: a cooling system that uses a heat source rather than a pump to provide the energy needed to drive the cooling system. (Southampton)

AirCycle: systems which use air under pressure to create heating and cooling. (AirCycle)

Anaerobic digestion: power generation through a series of processes in which microorganisms break down biodegradable material such as farm, food, and human waste in the absence of oxygen. (Holsworthy, Ginsters, Thurulie)

Biofilter: uses biotechnology to filter wastewater through naturally occurring organisms that remove nitrogenous and phosphorus waste. (Ginsters)

Bio-mass incineration: a waste to energy technology to generate energy and hot water. (Ginsters)

Cement stabilised soil: bricks and roadways composed of local soil with just sufficient cement to retain integrity, having excellent thermal properties and low embodied energy. (Thurulie)

Combined Heat and Power (CHP): Cogeneration of heat and power using heat created as a by-product of electricity generation for space or water heating. A thermodynamically efficient use of fuel. (Southampton, Holsworthy)

District energy: District energy is where energy (usually heat but also electricity or cooling) is supplied from one central source to multiple commercial and/or residential dwellings. (Southampton, Thurulie)

Energy Services Company (ESCO): a new business model that provides a broad range of comprehensive energy solutions including designs and implementation of energy savings projects, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management. (Southampton)

Ecological building design: a combination of design factors that allow a building to cause minimum ecological disturbance and energy use. Includes a range of design features and specific technologies such as building orientation and shading, local eco-climate, turf and reflective roofs, low embodied energy construction, low energy lighting. (Thurulie)

Evaporative cooling: Space cooling provided by the evaporation of water; especially well suited for climates where the air is hot and humidity is low. (Thurulie)

Geothermal energy: power extracted from heat stored in the earth. (Southampton)

Service utility: provision of e.g. compressed air as a utility in preference to selling compressed air equipment. (CompAir Airworx)

Small hydro power: electricity provision of <10MW from small and localised hydro schemes. (Thurulie)

Solar power: Use of solar panels to generate power. (Thurulie)

Water management: systemic use of waste and rain water for 'grey' water applications such as lavatory flushing. (Thurulie)

Windows: Traditional low tech devices which allow natural light and ventilation. (Thurulie)

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