This project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649397

AMBITION, VISION & ROADMAP
SMART BUILDINGS NEWCASTLE

D6.4 Final city report

18 August 2017

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R4E ROADMAPS FOR ENERGY®

AMBITION, VISION & ROADMAP SMART BUILDINGS NEWCASTLE

D6.4 Final city report

Leader: TU/e LightHouse

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Abstract

This report (D6.4) is the final deliverable of the R4E project and contains all relevant project results for smart buildings in the city of Newcastle.

The R4E project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649397.

Versions of this report:

18 August 2017	Concept for internal check by R4E partners (limited distribution)
xx Month 2017	Final version for public distribution

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R4E ROADMAPS FOR ENERGY®

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3-day workshop in each city to define specific ambitions per focus area

EINDHOVEN
ISTANBUL METROPOLITAN MUNICIPALITY – public transport, traffic mgt
Murcia
Newcastle City Council – domestic, non-domestic
Ajuntament de SantCugat
Tallinn
Murcia

Ambition sharing & selecting drivers for change
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3-day workshop in each city to develop specific desired future scenario's per focus area

Murcia
EINDHOVEN
Murcia
Newcastle City Council – domestic, non-domestic
Ajuntament de SantCugat
Tallinn
Murcia
ISTANBUL METROPOLITAN MUNICIPALITY – public transport, traffic mgt

Scenario sharing & selecting topics for roadmaps
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collecting expert insights with 20 experts for each focus area

SMART BUILDINGS
- Sustainable technologies
- Sustainable behaviour
- Sustainable organisation

SMART MOBILITY
- Sustainable technologies
- Sustainable behaviour
- Sustainable organisation

SMART URBAN SPACES
- Sustainable technologies
- Sustainable behaviour
- Sustainable organisation

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Roadmap workshops
2-day workshops in each city to develop specific timelines for the realisation of the desired future scenario's

EINDHOVEN
Tallinn
Murcia
Newcastle City Council – domestic, non-domestic
Murcia
Ajuntament de SantCugat
Murcia
ISTANBUL METROPOLITAN MUNICIPALITY – public transport, traffic mgt

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2-day meeting in Newcastle to share the roadmaps of the different cities, as well as the current projects, and to identify cross-learning objectives

New projects
each city identifies the desired new projects to ensure the timely realisation of its roadmap ambition

EINDHOVEN
Murcia
ISTANBUL METROPOLITAN MUNICIPALITY – public transport, traffic mgt
Newcastle City Council – domestic, non-domestic
Murcia
Murcia
Ajuntament de SantCugat
Tallinn

Joint portfolio meeting
3-day meeting in Forli to share the portfolios of the different cities, as well as to prepare for joint projects that support the achievement of common ambitions

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Strategy & visuals – developing a communication & dissemination strategy, logo's and graphic charter

Event – Palermo

Regular communication activities – electronic project newsletters, other newsletters and information services, project and partner websites, press releases and other media releases, social media

Event – Tallinn

Regular communication activities

Final event – conference in Murcia

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649397

ROADMAPS FOR ENERGY®

Version 4 September 2015

R4E - ROADMAPS FOR ENERGY

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Introduction

In the Roadmaps for Energy (R4E) project, the partners work together to develop a new energy strategy: their Energy Roadmap. The difference between the regular energy strategies and action plans and these new Energy Roadmaps is the much earlier and more developed involvement of local stakeholders. These include not only those who benefit from the new strategy, such as the citizens themselves, but also relevant research and industry partners. They offer a much clearer view of the future potential of the city in terms of measures and technologies, as well as of the challenges presented by today's situations in the cities. The result is a shared vision, containing the desired, city-specific scenarios and the dedicated roadmaps embedded in each city's specific context. These roadmaps take into account the diversity in the geographies, ecologies, climates, societies and cultures of the eight partner cities in the project: Eindhoven, Forli, Istanbul, Newcastle, Murcia, Palermo, Sant Cugat and Tallinn.

The R4E project focuses on the vision creation and roadmapping capabilities of the individual municipalities. This includes initiating joint activities to drive the development and implementation of innovative energy solutions in cities. In this way the R4E partners learn the process and the roadmap structure. At the same time they gain the skills they need to work independently on their future roadmaps.

The ultimate result is a process that allows the partners to work together in developing the Energy Roadmap to achieve their 'Smart Cities' ambition. Since energy and Smart Cities are too broad to cover in a single project, R4E focuses on three key areas of sustainable energy. These are closely linked to the main responsibilities of the municipalities:

SMART BUILDINGS

SMART MOBILITY

SMART URBAN SPACES

The three focus areas of R4E

Approach

The R4E project follows a 4-step approach:

1. The FIRST step sets the ambitions for the project. The ambitions of the participating cities on sustainable energy and Smart Cities in general are set, as well as the partner cities' choice of two (out of three) focus areas within Smart Energy Savings: Smart Buildings, Smart Mobility or Smart Urban Spaces.

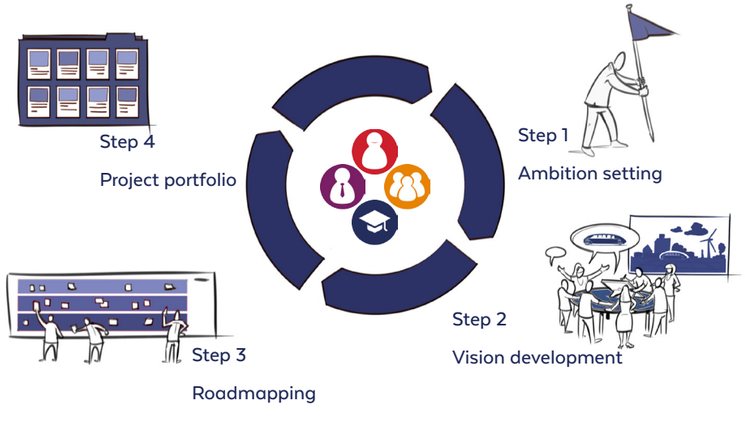
2. The SECOND step is to develop desired city scenarios for the selected focus areas.

3. In the THIRD step, the roadmap is created. This involves identifying existing and future technologies and other developments that will enable the desired future scenarios. The opportunities and developments are plotted on a timeline to show the route and milestones towards the favoured scenarios. The roadmaps contain common parts for all the partner cities, as well as specific parts for the individual cities.

4. In the FOURTH and final step, a project portfolio is generated with new projects and initiatives to reach the ambitions, visions and roadmaps of the cities. This portfolio provides an overview of individual and joint projects, and includes cross-city learning and financial plans.

The approach is characterised by four main elements:

- Backwards planning – the project starts with the development of a shared vision as a starting point for the creation of a well developed path to achieve it.
- Inclusive workshops in the cities – a cooperative process to engage key stakeholders (companies, citizens, public and private organisations and knowledge institutes) within the region in co-creating a clear and well designed implementation plan with a stronger commitment to the joint effort in the realisation phase.
- Expert knowledge is sourced in a practical and usable form during the vision development and roadmapping.
- A visual language is used to easily connect people and share main insights.



Four step approach of R4E

The R4E partner cities

EINDHOVEN

Gemeente Eindhoven, the Netherlands

- Population: 220,000
- Area: 90 km²

SMART MOBILITY · SMART URBAN SPACES

Newcastle City Council

Newcastle City Council, United Kingdom

- Population: 282,000
- Area: 114 km²

SMART BUILDINGS
- Domestic buildings
- Non-domestic buildings

Comune di Forlì, Italy

- Population: 120,000
- Area: 228 km²

SMART BUILDINGS · SMART URBAN SPACES

Comune di Palermo, Italy

- Population: 885,000
- Area: 160 km²

SMART BUILDINGS · SMART MOBILITY

ISTANBUL METROPOLITAN MUNICIPALITY

Istanbul Metropolitan Municipality, Turkey

- Population: 14,100,000
- Area: 1.830 km²

SMART MOBILITY
- Public transport
- Traffic management

Ajuntament de SantCugat

Ajuntamient de Sant Cugat del Vallès, Spain

- Population: 86,000
- Area: 50 km²

SMART BUILDINGS · SMART URBAN SPACES

Murcia

Ayuntamiento de Murcia, Spain

- Population: 440,000
- Area: 885 km²

SMART BUILDINGS · SMART MOBILITY

Tallinna

Tallinna Keskkonnaamet, Estonia

- Population: 430,000
- Area: 160 km²

SMART BUILDINGS · SMART MOBILITY

The eight partner cities of R4E

Newcastle City Council












AMBITION SETTING

SMART BUILDINGS

Ambition Setting

The aim of Step 1 is to set the ambitions for the project. An ambition expresses what a city wants to achieve in the future. For this purpose the ambitions of the participating cities on sustainable energy in general are defined and refined in a process of co-creation, using existing policy documents as a basis for workshops with the individual cities. Each city selects two focus areas for which specific city ambitions are defined.

Today's reality

During the kick-off meeting the cities present the current status of their energy policy in general and their selected focus areas in particular. This chapter starts with a summary of this information.

Ambition Workshops

The strategic ambitions for energy-related themes in general and for the selected focus areas in particular are assessed in a series of workshops in each of the partner cities.

The Ambition Workshops consists of 3-day visits to the individual cities, during which several workshops with policy-makers and stakeholders are held to gain a deep understanding of the ambitions and specific contexts of the cities. Through the networks in the cities the local stakeholders (companies, citizens, public and private organisations and knowledge institutes) are invited to participate in the workshops. Together, the participants interactively contribute to the strategic ambitions. See also the pictures of the workshops on the previous page. The results of the Ambition Workshops are reported in similar formats for each of the cities to enable cross learning between the cities.

Day 1	Day 2	Day 3
Interview with policy makers	Workshop with stakeholders focus area 1	Project team working session to establish scope
Workshop with strategy department	Workshop with stakeholders focus area 2	Preparing main content of concept report

Programme of the Ambition Workshops in the cities

Joint Ambition Workshop

In a joint meeting in Palermo, the cities shared their ambitions and held in-depth discussions to understand the common and specific aspects of their ambitions. The main aim of the Joint Ambition Workshop is to enable cross-city learning. In this way the cities gain a deeper understanding of the Ambition Setting process, and can improve their own ambition with inspiration from others.

The Joint Ambition Workshop is a 1-day workshop that finalises the activities of Step 1 and prepares for Step 2.

Morning Finalising Step 1	Presentation of the cities ambitions • Each city presents their ambition for the focus areas
	Learning from each other's ambitions • In-depth discussion on common and specific ambitions
Afternoon Preparing for Step 2	Presentation of the Drivers for Change • Sharing of results of Future Telling research
	Understanding the Drivers for Change • Exploring the relevance for the focus area and selection of drivers for scenario workshops

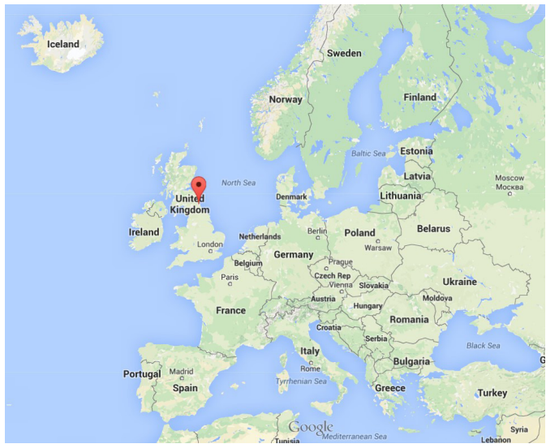
Programme of the Joint Ambition Workshop

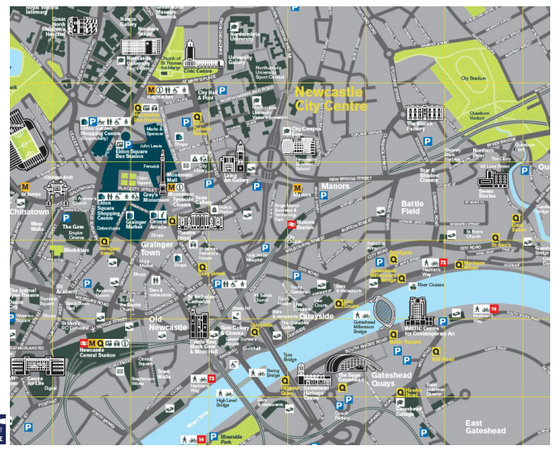
Introduction to Newcastle

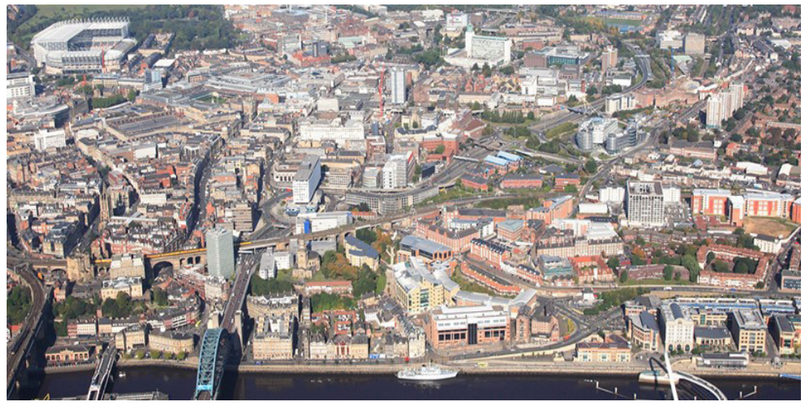
Introduction to the city

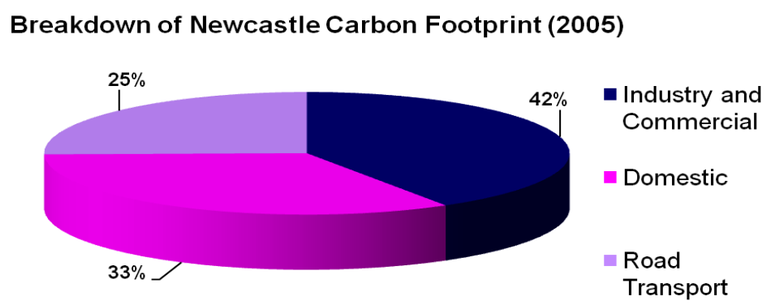
Newcastle upon Tyne, commonly known as Newcastle, is a city in the metropolitan county of Tyne and Wear in North East England. Located 120 miles (193 km) south of Edinburgh and 280 miles (450 km) north of London, it is situated on the north-western bank of the River Tyne estuary and is 8.5 miles (13.7 km) from the North Sea. Newcastle is the most populous city in the North East region, and lies at the urban core of Tyneside, the seventh most populous conurbation in the United Kingdom and the most populous in the North East. Newcastle is a member of the English Core Cities Group and, together with nearby Gateshead, is part of the Eurocities network. Newcastle was part of the county of Northumberland until 1400, when it became a county in its own right, a status it retained until becoming part of the Tyne and Wear metropolitan county in 1974. The regional nickname and dialect for people from Newcastle and the surrounding area is 'Geordie'.

The city developed in the location of the Roman settlement called Pons Aelius. It was named after the castle built in 1080, by Robert Curthose, William the Conqueror's eldest son. The city grew as an important centre for the wool trade in the 14th century, and it later became a major coal mining area. The port developed in the 16th century and, along with the shipyards lower down the river, was among the world's largest shipbuilding and ship-repair centres. Newcastle's economy includes corporate headquarters, learning, digital technology, retail, tourism and cultural centres, from which the city contributes £13 billion towards the economy of the United Kingdom. Among its main icons are Newcastle Brown Ale, a leading beer brand; Newcastle United F.C., a Premier League football team; and the iconic Tyne Bridge. It has hosted the world's most popular half marathon, the Great North Run, since it began in 1981.









SMART BUILDINGS

Newcastle upon Tyne local authority carbon emissions

Year	A	B	C	Total
2005	2.9	2.5	1.7	7.1
2006	3.0	2.4	1.6	7.0
2007	2.8	2.3	1.6	6.8
2008	2.9	2.3	1.6	6.7
2009	2.6	2.1	1.5	6.1
2010	2.8	2.2	1.5	6.4
2011	2.4	1.9	1.4	5.7
2012	2.6	2.0	1.4	6.0
2013	2.5	1.9	1.3	5.8
Units	t CO2 per person			

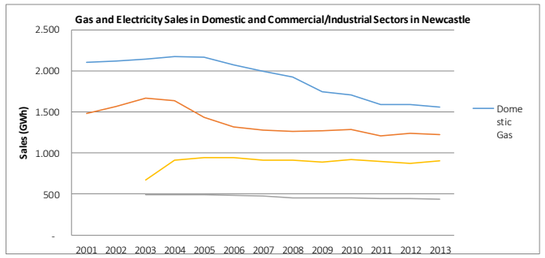
A = Industry and Commercial

B = Domestic

C = Transport

Source: https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-2013

Trend data, Newcastle upon Tyne for gas and electricity in domestic and commercial



Source: https://www.gov.uk/government/statistical-data-sets/regional-and-local-authority-electricity-consumption-statistics-2005-to-2011

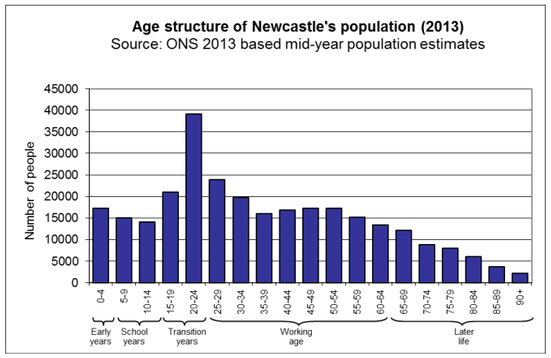
Demographical aspects

Number of inhabitants

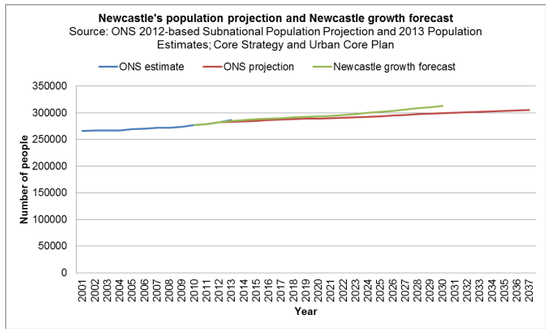
The latest ONS population estimates (2013) suggest there are approximately 286,800 people currently living in Newcastle.

Census 2011 and ONS 2012-based Sub-national Population Projections. Source: Population Projections Unit, ONS. Crown copyright 2014.

Graph: age structure of the population

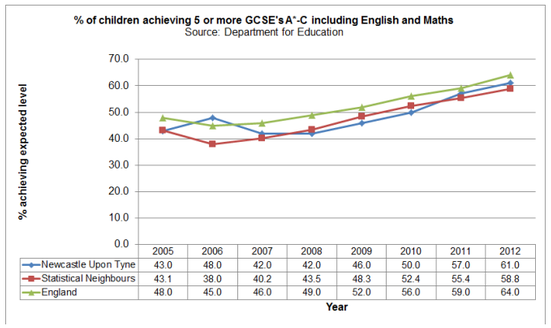


Graph: population growth forecast



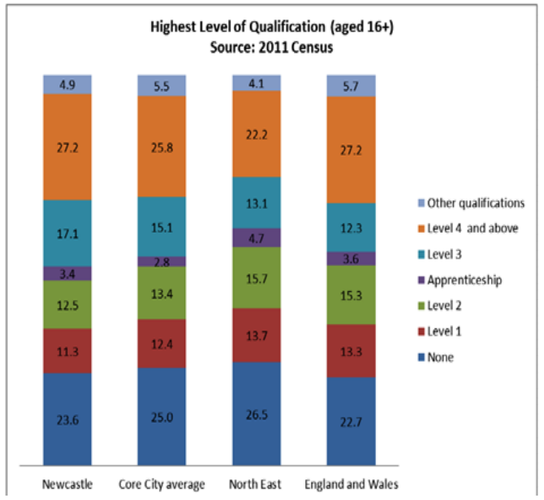
Social aspects

Graph: Children educational achievements



	2005	2006	2007	2008	2009	2010	2011	2012
Newcastle Upon Tyne	43.0	48.0	42.0	42.0	46.0	50.0	57.0	61.0
Statistical Neighbours	43.1	38.0	40.2	43.5	48.3	52.4	55.4	58.8
England	48.0	45.0	46.0	49.0	52.0	56.0	59.0	64.0

Graph: Highest level of qualification



In the year to June 2013, the Newcastle unemployment rate was 11.1%.

Source: http://www.wellbeingforlife.org.uk/sites/default/files/2.5%20Activities.pdf

The estimated proportion of households on fuel poverty is 13%. That is 15.344 households out of the total number of 118.362 in Newcastle upon Tyne.

Source: https://www.gov.uk/government/statistics/2013-sub-regional-fuel-poverty-data-low-income-high-costs-indicator

Census 2011 suggests 18.7% of people in Newcastle have a long-term health problem or disability that limits their day-to-day activity to some degree, a reduction from 21.6% in 2001. Of the 18.7%, just over half are limited 'a lot' (26,661 people) and the rest 'a little' (25,916).

Source: http://www.wellbeingforlife.org.uk/sites/default/files/People%20living%20in%20Newcastle%20-%20B.pdf

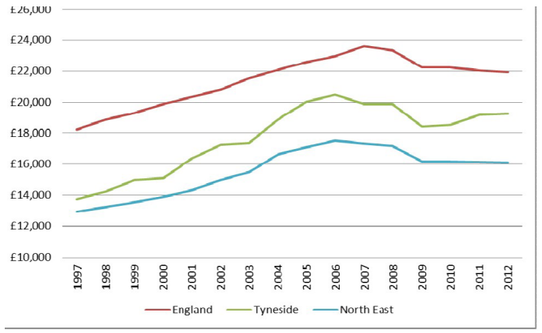
In 2010, Newcastle conducted a Private Sector House Condition Survey against the Decent Homes Standard. The Survey identified that:

- 23.4% of private dwellings (including owner occupied and private rented) were not in the condition to achieve the standard.
- 32.5% of private rented properties were not in the condition to achieve the standard. Within this group one quarter were properties where the occupiers were classed as vulnerable, such as people on low incomes, people with disability and people in later life. These people can all be particularly affected by the state of their home.

Economical aspects

Gross Disposable Household Income (GDHI) for Tyneside is 81% of the UK average GDHI, which is similar to other large urban areas (Figure 2.6-8). Low income is consistent with the economic challenges discussed elsewhere in Know Your City, such as high unemployment rates and a shortage of highly paid jobs. Figure 2.6-8: Gross Disposable Household Income as a percentage of UK average.

Source: ONS Regional GDHI (2012) http://www.wellbeingforlife.org.uk/sites/default/files/2.6%20Local%20economy.pdf



The graph shows that over time, GVA for the North East as a whole is lower than the England average, however Tyneside is higher than the North East average. This low rate of GVA in part reflects low employment rates, relatively low skills, and comparatively few higher-paid jobs.

http://www.wellbeingforlife.org.uk/sites/default/files/2.6%20Local%20economy.pdf

Graph: Jobs per 100 residents (aged 16-64) by sector. It shows that Newcastle has a particularly high concentration of employment in service sectors and comparatively few manufacturing jobs. The service sectors and successful higher education institutions are particular strengths. Weaknesses include a relatively small number of private sector businesses and higher public sector employment in a period of ongoing spending cuts.

Http://www.wellbeingforlife.org.uk/sites/default/files/2.6%20Local%20economy.pdf

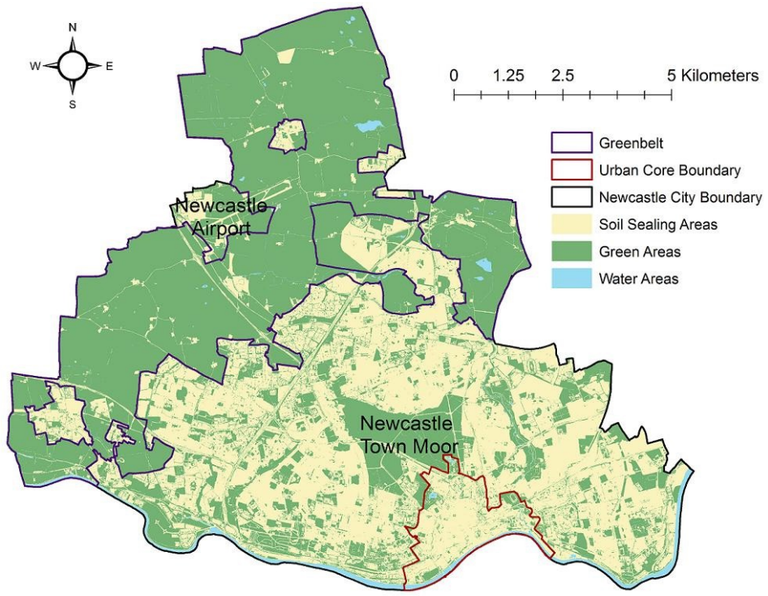
Broad Industrial Group	*Newcastle*	*NELEP*	*England*
Agriculture, forestry & fishing	0.0	0.0	1.0
Mining, quarrying & utilities	0.1	0.9	0.8
Manufacturing	4.4	6.9	5.9
Construction	2.3	3.1	3.2
Motor trades	1.0	0.9	1.3
Wholesale	1.0	1.2	2.9
Retail	8.8	6.7	7.2
Transport & storage	3.2	2.1	3.2
Accommodation & food services	7.2	4.4	4.8
Information & communication	3.8	1.7	2.8
Financial & insurance	3.2	1.4	2.7
Property	2.0	1.1	1.3
Professional, scientific & technical	6.8	2.7	5.6
Business administration & support services	7.7	4.5	5.9
Public administration & defence	9.2	5.0	3.2
Education	10.5	6.1	6.5
Health	15.6	9.5	9.0
Arts, entertainment, recreation & other services	5.4	2.9	3.1

Environmental aspects

The total area of the city is 122.85km2, with green space making up 67.72km, or 55%. This space is reasonably evenly distributed across the city, with the town moor at its heart.

Publically accessible green space:

Type of green space	Area (km^2)	Percentage coverage of all publically accessible green spaces
Allotments, community gardens and urban farms	1	5.87
Amenity green space	4.22	24.75
Cemetery or churchyard	0.68	3.99
Green corridor	0.16	0.94
Natural and semi natural green spaces	5.49	32.20
Outdoor sports facility (inc. schools)	2.94	17.24
Parks and gardens	2.54	14.90
Provision for children and young people	0.02	0.12

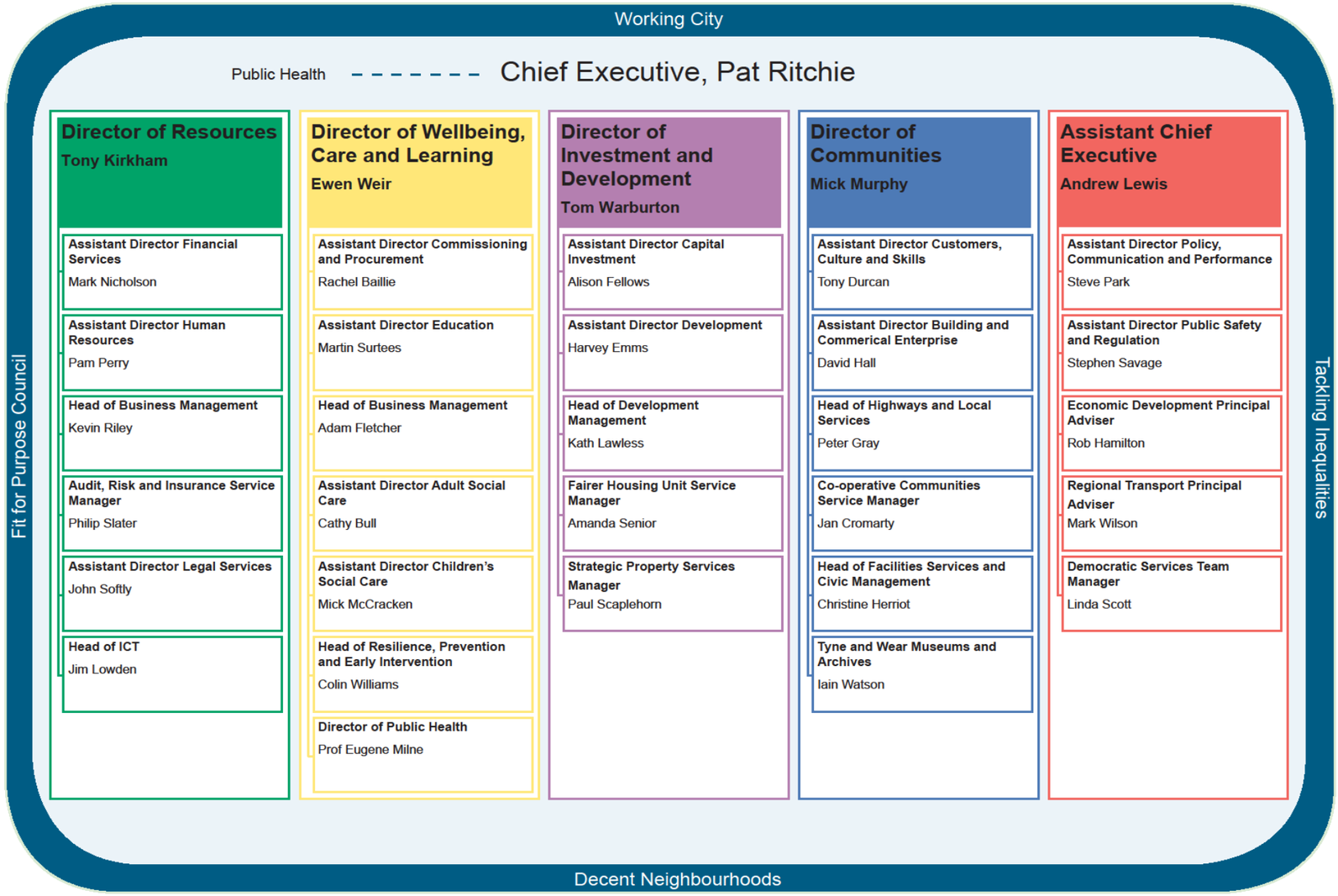


SMART BUILDINGS

Way of Working

Organisational chart of the relevant departments in the municipality

Http://www.newcastle.gov.uk/your-council-and-democracy/policies-plans-and-performance/our-policies-and-plans/council-plan/vision-values-and-priorities



Newcastle has selected two focus areas for the R4E project:

SMART BUILDINGS

- Smart domestic buildings
- Smart non-domestic buildings

Today's reality: Smart domestic buildings

The domestic buildings includes 122,000 properties in Newcastle, which contribute 33% of the CO_2 generated by the city. Reducing the CO_2 generated in the domestic sector not only makes a substantial contribution to the overall targets, but will also contribute to improving living standards by helping to reduce 'fuel poverty' and improving the physical condition of the property.

A residents' survey gives some insights into respondents' satisfaction with their homes and their local areas as a place to live. The survey is carried out every one or two years — most recently in 2012.

How satisfied are you with your home as a place to live?

	2008/9* %	2009	2010 %	2012
Satisfied	86	88	88	86
Neither	6	5	7	8
Dissatisfied	7	7	6	6
Total	**100**	**100**	**100**	**100**

How satisfied are you with your local area as a place to live?

	2007 %	2008/9* %	2009 %	2010 %	2012 %
Satisfied	75	79	79	80	77
Neither	10	12	10	11	9
Dissatisfied	15	9	12	9	14
Total	**100**	**100**	**100**	**100**	**100**

Source: http://www.wellbeingforlife.org.uk/sites/default/files/2.4%20Built%20environment2.pdf

15 December 2015

Adrian MCLOUGHLIN, Newcastle City Council (NCC)

Ambition: Smart homes enabling a high quality of life in Newcastle 2050

SMART BUILDINGS

1

Comfortable housing, affordable energy

In 2050, residents of Newcastle value living in the city because of the high quality of life and comfortable housing. Good data management supports an effective energy system, in which all the homes have zero energy usage from the grid. Controllability is achieved by new collaboration and business models for sustainable energy solution. These make energy accessible and affordable for all, in both new and existing housing.

Strategic ambitions

- In 2050 Newcastle domestic buildings have zero energy import from the grid.
- In 2050 the energy system is affordable, accessible, sustainable and fair.
- In 2050 all domestic housing enjoy energy efficient, comfortable and de-carbonised heating. Affordable retrofitting solutions and suitable business models have made it possible for all residents in both existing and newer housing to install such solutions.

2

Empowering residents

In 2050, residents of Newcastle have the means and the wish to make responsible choices in their energy usage. Retrofitting domestic heating systems and adding intelligent controls enables the most efficient, low-carbon options. At the same time it creates jobs in the local economy and helps to tackle fuel poverty. Residents are empowered to control their own energy usage, ensuring affordable, low-carbon heating and enabling healthy, safe energy consumption levels.

Strategic ambitions

- In 2050 the residents of Newcastle have the means and the desire to control their energy environment and make responsible choices.
- In 2050 fuel poverty is zero.
- In 2050 energy consumption in households uses a more diverse range of technologies. Distributed power generation, electrification of heat and connection to district systems are the norm. Other sources of local heat could include geothermal and a wider variety of heat pumps. This more complex, more local energy system offers jobs to the local economy; Many of the traditional jobs in the fossil fuel sector have diversified into the green economy, (e.g. services for offshore wind).

3

City leadership

In 2050, Newcastle City Council is valued for its strong leadership and clear vision. It has created a sustainable society, in which people themselves take responsibility and set the right example. Through the open data centre the City Council and its partners are able to implement evidence-based policies and decision-making. Through consistent, evidence-based programmes, partnerships have created a secure, self-sufficient and low-carbon energy system for the city.

Strategic ambitions

- In 2050 Newcastle City Council considers the local (regional) authority footprint, looking beyond the boundaries of a house, of a property, of a land ownership and creating shared responsibility.
- In 2050 Newcastle is low-carbon energy secure and self-sufficient.
- In 2050 Newcastle City Council benefits from their clear message, strong leadership and leadership by example.

Today's reality: Smart non-domestic buildings

Newcastle City Council

Newcastle has a primarily service-based economy, with very few 'heavy' producers of CO_2. Within the private sector, this is distributed across the provision of professional services, financial services and a dominant retail and leisure sector. In this regional capital, the public sector is a significant operator with two universities, several major hospitals and central government agencies located in the city. The total number of non-domestic buildings in Newcastle is 7,283.

15 December 2015

Simon JOHNSON, Newcastle City Council (NCC)

Ambition: Smart buildings and infrastructure enable a thriving economy in Newcastle 2050

SMART BUILDINGS

1

Fit-for-purpose, energy efficient buildings

In 2050, occupants and users of non-domestic buildings in Newcastle enjoy flexible, energy-efficient spaces which they can easily adapt to their own, changing needs. They use on-going retrofit solutions to adapt the buildings to their specific usage and maximise efficiency. Buildings are exemplary in the use of innovative, sustainable technologies. High visibility of the solutions contributes to a thriving building sector that 'exports' design and consulting services. Newcastle City Council shows leadership and informs, supports and cooperates in creating efficient buildings.

Strategic ambitions

- In 2050 all buildings are as efficient as they can be with the newest technologies, despite when they were built. All buildings are flexible adaptable to changing occupancy needs and user requirements. The use of innovative solutions is visible in the city.
- In 2050 the buildings in Newcastle are affordable and fit-for-purpose. Occupants will have the necessary technology to flexibly adapt the spaces to their needs.
- In 2050 Newcastle is a leader in a smart cities approach and an exemplar in sustainable energy efficient buildings. This approach is adopted by all stakeholders. The City Council is a national leader in driving business participation through policy making and by getting things done.

2

Collective approach to infrastructure

In 2050, Newcastle has adopted a collective approach that enables joint decision-making with partners and stakeholders in the city. All buildings are smart – so they both receive and transmit information – and are connected to a physical infrastructure of all kinds of networks (grids, transport, heating, electricity, data etc.). Urban planning takes a broad, wide-area view to take full advantage of opportunities extending beyond site boundaries and city limits.

Strategic ambitions

- In 2050 a collective approach is realised that enables joint decision making as well as a physical infrastructure that connects all buildings. In urban planning a broader view and wider area is considered to link smart buildings into smart grids to reap the opportunities beyond the specific site boundaries
- In 2050 Newcastle City Council has both direct service provision and a strong mix of innovative, collaborative and cooperative models for partnership and participation that supports the smart development of the city.

3

Vibrant economy, happy people

In 2050, Newcastle has a thriving economy based on new industries that attract young people. The smart buildings policy makes the city attractive to investors, resulting in new jobs and new forms of collaboration with stakeholders. Citizens enjoy high-quality facilities, community life and an attractive, green living environment.

Strategic ambitions

- In 2050 Newcastle has a vibrant economy based on new industries (like digital and software) that attract young people.
- In 2050 the city of Newcastle is a catalyst for job creation and industry investments for ethical and environmental developments.
- In 2050 Newcastle is internationally recognised as an innovative area where investments are rewarded through policy. Collaboration between policy and businesses is facilitating continuous investments for a sustainable city.
- In 2050 the outcomes of the smart buildings policy are visible and explicitly of value to all stakeholders, in the sense of health, jobs, cooperation, citizens and community experience. The economy is vibrant, with green jobs, maximising the potential of the city.
- In 2050 Newcastle attracts young people with a growing economy and attractive living environment (facilities, entertainment options, walking and cycling routes). The jobs in the gas/oil industry have been replaced by new jobs in the green economy (such as services for off-shore wind). The new economy in e.g. software and digital industries benefit from Newcastle's heritage as international trading city.

Creating the visual of the desired future scenarios

VISION DEVELOPMENT

Vision development

The aim of Step 2 is to develop visions for the cities on the selected focus areas. A vision is based on a long-term perspective on the world — in this case we are focusing on 2050. Two main activities take place in this step: Future Telling research and the development of the desired future scenarios in the cities.

Future Telling

The first part of the vision development activity is to identify Drivers for Change that influence the future of Smart Cities in general, as well as of Smart Buildings, Smart Mobility and Smart Urban Spaces in particular. The Future Telling research method develops context-related possible future scenarios in a creative and imaginative way and leads to Drivers for Change for liveable Smart Cities in 2050.

The method is briefly described on the following pages and more elaborate in the Future Telling 2050 D2.1 Report — Drivers for Change.

Developing desired future scenario's

Of the 18 Drivers for Change for Smart and Sustainable Cities, the cities chose four Drivers for Change for each focus area that relate best to their specific contexts and ambitions.

Together with the ambitions of step 1, these are used to develop the desired future scenarios for the focus areas.

Scenario Workshops

The desired future scenarios for the selected focus areas of the cities are created in a series of workshops held in each of the partner cities. These Scenario Workshops consist of a 3-day programme in each city, and include sessions with policy-makers and stakeholders to develop a rich, contextual scenario for the city. Local stakeholders (companies, citizens, public and private organisations and knowledge institutes) are invited to take part in the workshops through the networks in the cities. The results of the Scenario Workshops are reported in the same format for each city to facilitate cross-learning between the cities.

Two sessions are held for each focus area. In the morning session the outline for the vision and the desired future scenario is developed. The main stakeholders work with the set ambition for the focus area and the selected Drivers for Change to understand their impact on the city in 2050. Together, the participants define the main elements of the vision. Then, in the afternoon session, a broad spectrum of stakeholders are invited to enrich the desired future scenario by making specific additions. Based on the outlined vision, they carry out a further in-depth exploration of the main elements of the vision. In all the sessions, the participants interactively build a visualisation of the desired future scenario. See also the pictures of the workshops on the previous page.

The result of the vision development step is a visualisation of the desired future scenario in an A0-format poster. The poster shows the visual together with a brief explanatory text. A common visual language is used to make sharing easier and to facilitate discussion among the cities on common and specific aspects of the visions.

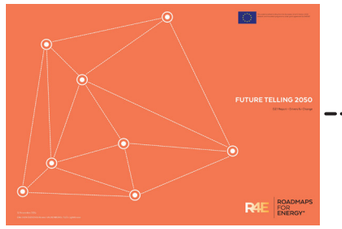
Joint Vision Workshop

In a joint meeting in Istanbul the cities presented their desired future scenarios to each other, and held in-depth discussions to understand the common and specific needs in their visions.

This Joint Vision Workshop served two purposes:

- To enable cross-city learning. The cities gain a deeper understanding of the vision development process, enabling them to improve their own vision with inspiration from others.
- To describe the needs as input for the roadmapping step.

The Joint Vision Workshop finalised the activities of Step 2 and prepared for Step 3.



Future Telling 2050 - D2.1 report - Drivers for Change

Ambition Setting - D1.1 report - Specific ambitions of the R4E partner cities

City scenario workshops	Day 1 - Focus area 1	Day 2 - Focus area 2	Day 3 - Reporting
	Outlining the vision • Exploring the drivers for change in relation to the future of the city • Selecting the main elements of the vision	**Outlining the vision** • Exploring the drivers for change in relation to the future of the city • Selecting the main elements of the vision	Project team working session to prepare the report of the Scenario Workshop
	Enriching the desired future scenario • Exploring the future the city and the main elements of the vision • Enriching the vision with specific additions	**Enriching the desired future scenario** • Exploring the future of the city and the main elements of the vision • Enriching the vision with specific additions	

Programme of the scenario workshops in the cities

Day 1 Finalising Step 2	**Poster exhibition of the city visions** • The cities share their desired future scenarios for the focus areas
	Learning from each other's visions • In-depth discussion on common and specific needs described in the visions
Day 2 Preparing for Step 3	**Presentation of the Roadmapping process** • Sharing of interim results of the roadmapping desk study
	Identifying topics and experts for the roadmap interviews • Selecting topics for the roadmapping interviews and making a list of suggested experts using the networks of all partners

Programme of the Joint Vision Workshop

Newcastle City Council

Future Telling & selection drivers for change

SMART BUILDINGS

Future Telling research

The future is unpredictable and elusive. Recent changes in technology, ecology, economics and society have already led to significant changes.

The expectation is that the complexity that people and organisations experience will only increase further in the years ahead. A number of current Drivers for Change will lead to radical changes in the future. For example, new developments in information technology will create opportunities that we cannot imagine today. These will undoubtedly change our lives significantly, including the way we shop, travel, move, communicate and work. Another example is the increasing level of social connectivity, which will drastically affect the relationships between organisations and their strategies. Even today, disruptive developments in many areas are challenging us to redesign our world.

This constant process of change has also become more complex: developments are so rapid that the future is unpredictable, based on our knowledge and models of the past and present. Predictions based on analysis appear pointless. The new complexity is characterised by simultaneous developments with far-reaching effects. We need a new way to visualise the future, with all the opportunities and challenges that it will bring – an approach that is creative, imaginative and research-oriented. Even though we can't predict the future, we can create a range of possible context-related future scenarios. These desired scenarios will direct our decision-making, from short-term actions to long-term consequences.

In the R4E project, the Future Telling research method is used to develop possible, context-related future scenarios in a creative, imaginative way. This implies a structured method to map the expertise and ideas of the thought leaders. The process focuses on Smart Cities, in particular using analysis to gain insight into the Drivers for Change for cities in 2050.

Thought leaders

Finding suitable Drivers for Change requires both broad and specialist views. The research involves 25 interviews with thought leaders holding different views on smart and sustainable energy in cities. A broad spectrum of experts with a visionary scope was chosen from knowledge institutes, companies, consultancies and profit or non profit organisations. Their expertise was both general on (smart) cities, and specific on mobility, buildings and urban spaces.

To overcome possible cultural bias, the experts were drawn from all over Europe, and even included thought leaders from the USA. These thought leaders are introduced on the following pages. For the interviews, the requested expertise of the thought leaders was not specifically their future vision, but their knowledge of important influences in their own fields. The Future Telling method inspired them to use their knowledge to visualise future trends and to describe possible future scenarios in rich stories. In fact, the richness of those stories makes them fertile input for the R4E project.

Future Telling card set

The Future Telling method uses a set of 52 cards showing general future trends derived from an extensive research project by The Hague University of Applied Sciences. The cards are shown on the previous page. They are used to trigger ideas by the research participants, and to inspire them to tell rich stories about how they think these trends will influence the future.

Structured interviews

The Future Telling card set is used in the interview. The interviewees are asked to identify relevant future trends and to tell stories about how they imagine these trends could develop.

The card set with a broad collection of general trends helps in the interviews with specialists by making them consider all the relevant directions (social, technological, economic, ecological, political and demographic), and at the same time to consider more distant future scenarios. The trends that are presented on the cards trigger their thinking, and inspires them to give rich descriptions of how they see the future developing in relation to energy in cities in 2050.

The interviews contain three main questions:

1. Sort the 52 trends on the cards into three categories:

- Not relevant in the context of smart and sustainable energy in cities
- Already relevant now
- Relevant in the future

2. Take the selected cards in the category 'relevant in the future' and pick the 10 cards that in your opinion will have the greatest impact on quality of life (or lack of it) in cities in the context of smart and sustainable energy. (The interviewees can also add missing trends which they regard as important.)

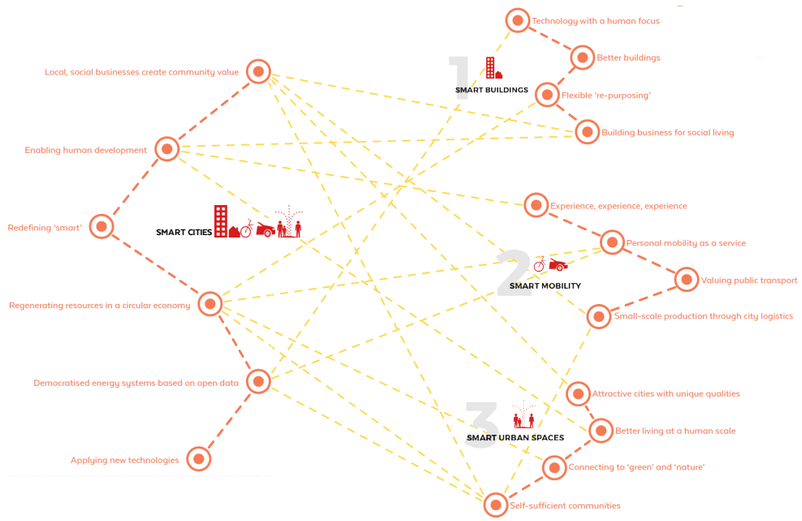
3. Tell stories about how you imagine these 10 trends will develop and what the future in cities will look like.

Drivers for Change

A limited yet representative number of Drivers for Change are distilled from the large volume of expert material. In this phase, the data from the interviews is analysed by means of clustering, selecting and comparing the quotes by the thought leaders. The clustering is based on both commonalities and contradictions in the statements by the experts on the specific topics.

A Driver for Change needs to address the topic of a cluster, as well as to point in the directions that the future might take. So for each cluster, a short title and a description are given to capture the richness of that cluster. The quotes by the though leaders serve as an inspiration to paint richer stories of the possible new future scenarios.

The analysis led to 18 Drivers for Change for the future of sustainable and liveable cities in 2050. We identified Drivers for Change at the general and smart city levels, as well as more specific Drivers for Change for the future of buildings, mobility and urban spaces.



18 Drivers for Change resulted from the Future Telling research
For an complete description, please refer to the complete report on Future Telling 2050 - D2.1 report Drivers for Change.

Selection of Drivers for Change

For the focus area Smart Domestic Buildings the city of Newcastle selected four Drivers for Change:

- Better buildings
- Technology with a human focus
- Building business for social living
- Applying new technologies

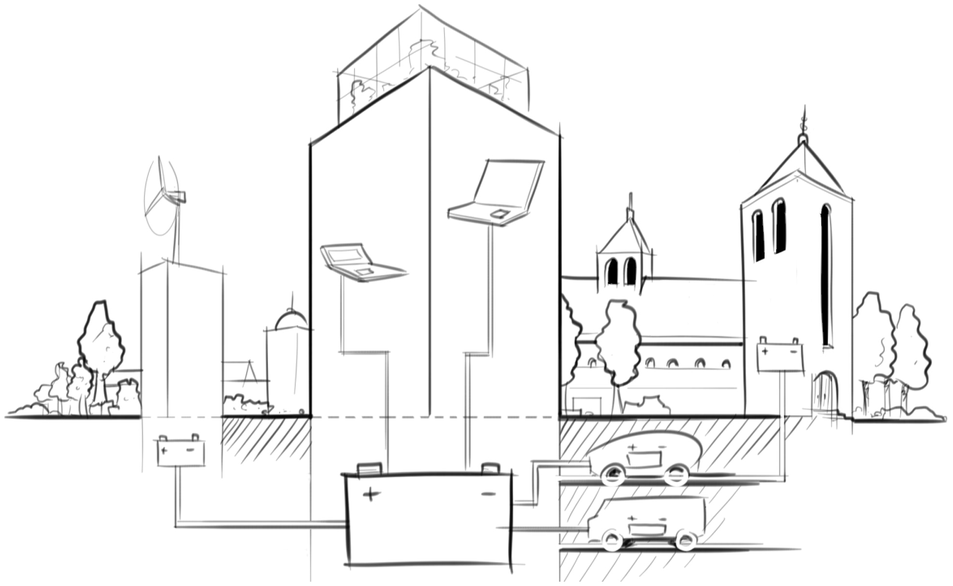
For the focus area Smart Non-Domestic Buildings the city of Newcastle selected four Drivers for Change:

- Flexible 're-purposing'
- Enabling human development
- Democratised energy systems based on open data
- Regenerating resources in a circular economy

The following pages give brief descriptions of the chosen Drivers for Change stating the essence of the changes. These are supported by a few quotes from the experts.

Better buildings

In 2050, new buildings combine historical qualities and new technologies, creating maximum comfort and functionality for their users. Historical expertise in building for specific local climates is used to design solutions for new buildings, and for thoughtful upgrading of those already existing. The latest technologies and materials are applied to make buildings self-sufficient or even energy positive, contributing to abundant of renewable energies in cities. Policies aim at improving the quality of neighbourhoods and strengthening the sense of community, and not only at reducing energy consumption.



This Driver for Change represents the following cluster of quotes of the thought leaders:

a. Blending the quality of our architectural past with the opportunities of new technologies

FT15.02. By 2050 we will be in a scenario where the building itself stores the energy that it needs. .... Today, even in this building, there is a lot of energy stored in every battery in every machine, but they are not connected to one another. There is a lot of cars parked underneath this building, and whether there will be cars in the future or cars will be slightly different, but there will be battery powered mobility. So all of that collective energy can plug into the building, to pair with the building. And buildings can then plug in into other buildings and share all this energy that is there.

FT23.05. ... because the climate change is a reality, it will effect more the lower class people. Which is a big number of people in Europe these days. Last year, we had a big crisis and people did not use any gas and energy for cooking anymore. They were reducing the amount of energy because they were not able to pay the bills. We need to be very careful about these things. Energy savings in this way is easy, ... I believe we should make policy that is not aiming for reducing energy, but aim for increasing the quality of fabrics and buildings. But if you are not able to explain why this is necessary, then it will not work, because no one will invest money voluntarily to do that.

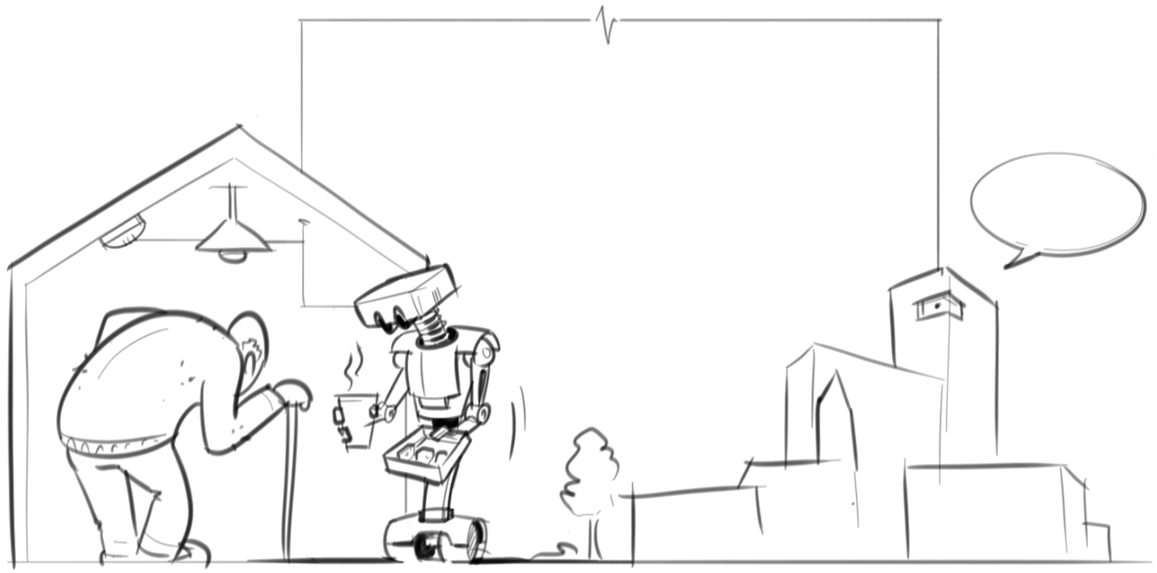
FT22.15. We also have the problem of social housing that were built in the last decades and all these houses are very bad. Poor constructions, poor systems. After the second World War the set-up, of cities of houses, has been forgotten. There is now no more money to change completely. The problem is that these neighbourhoods become the place where the new people will stay and that creates a lot of conflicts.

FT7.18. In 2050 you will get windows with electricity generating capacity in them. And smarter houses, and new infrastructure for electricity with IQ as we say. A lot will happen in new and refurbishing old buildings.

SMART BUILDINGS

Technology with a human focus

In 2050, we've mastered the challenge of ever more complex, multifunctional systems and the need to make them easier to use. Those systems are user-focused: that means users can understand how the systems work, and how their own behaviour affects sustainability and energy use. Robotics and smart (home care) systems support living at home, helping people to live healthier lives and to stay in their homes longer as they get older. There's a range of available solutions that plug-in directly to the city's open energy platform.



This Driver for Change represents the following clusters of quotes of the thought leaders:

a. Smart systems with a human touch

b. Improving quality of life with robotic support and home care systems

FT22.12. It is important to invest constantly. So people understand immediately the advantages of new technologies for sustainability in buildings and houses. Just to save electricity or for condition, because they immediately save money. That is very easy to understand. This requires a change for the experts to develop good scenario's. Not in the far future, or even the future, it starts right now. They have to present in a way that people easier understand.

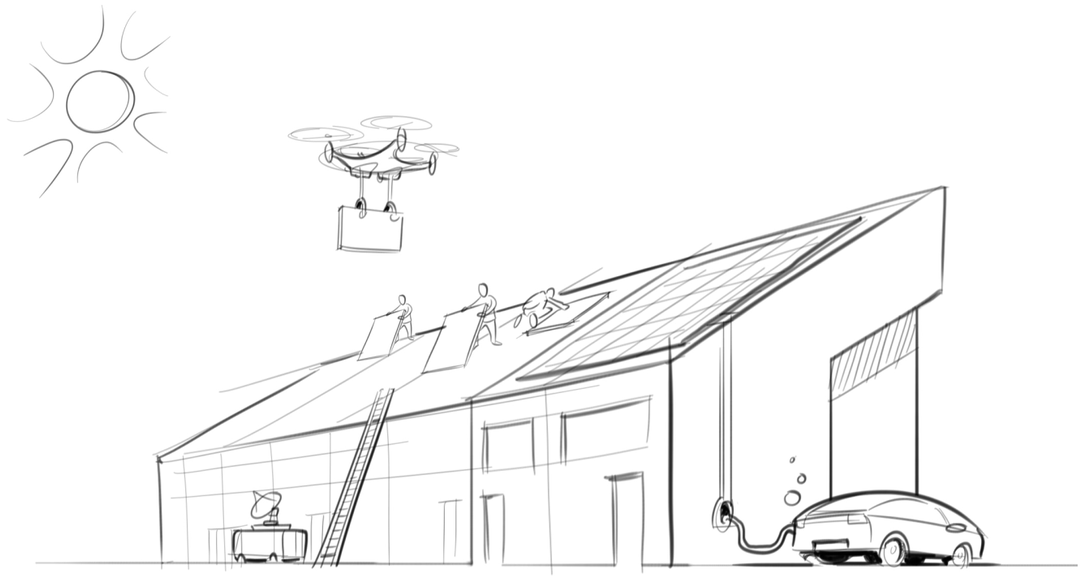
FT15.13. Now today there is things you can do in the home and around to save energy. ... The value in Euros is not worth much. And I don't think honestly that most home owners want to reduce their energy bill either. They just don't want it to go up. ... We have the technology to help you do that. Some of these technologies even mean that they can help to reduce your bill. So you could save 5 Euros a month. If you could translate that 5 Euros into something that is valuable. So if you say look, if you allow us to join you, or to involve you in this response-demand program, you will see no reduction in your home comfort, the heating will be on, etc. And we will take those credits and with those credits, we will give you another system in the elderly home where your mother lives, 300 miles away. It is very simple, you can set a scenario, that if the lights do not get on between 7-8 in the morning, or she doesn't put the kettle on between 7-8, then we will send you a text message and you can ring her up to see if she is alright. ... So instead of the 2 or 3 Euros, translate that into a service that is very cheap to deliver but of a very high value to the individual. The challenge around utilities is to engage with the customers.

FT23.01. ... This is the weak part of the story. If we do not speak about these weak elements of the society in the suburbia, then there is no way to talk about energy. Energy is invisible, people do not see it and do not understand it. They do not know where energy comes from and they do not connect the fact that you have energy and that creates problems in terms of emissions and pollution. So if you do not connect to that idea that energy has an impact on everybody, then you can never win.

FT 15.17. ... Interesting will be the lighting. If you want more lighting, and you want to turn the switch, you are actually saying 'I want more light for reading'. Now the building can do anything to his ability to analyse and see if it does so by letting more lights in from using the blinded windows or change the transparency of the walls. It will do whatever the most efficient solution is to give you what you need. And then as a last resort, okay turn the light on. The switch of tomorrow is just a sensor and the robotic support mechanism will change walls, windows, blinds, everything to help you get what you need.

Building business for social living

In 2050, suitable financing structures and revenue models are available, offering solutions that are affordable while also boosting the local economy. Both individuals and small communities act as entrepreneurs. They benefit from good infrastructure and technology options, so they can self manage and at the same time improve their lives and the living environment.



This Driver for Change represents the following cluster of quotes of the thought leaders:

a. Affordable solutions fostering the local economy

FT19.03. Suppose becoming self-sufficient will come available for every household at 20.000 Euro's. That means from then on energy is free, so it is relevant for every household. Some may not have the money to invest. So you need some financial instruments to do so. That is a very relevant condition to create.

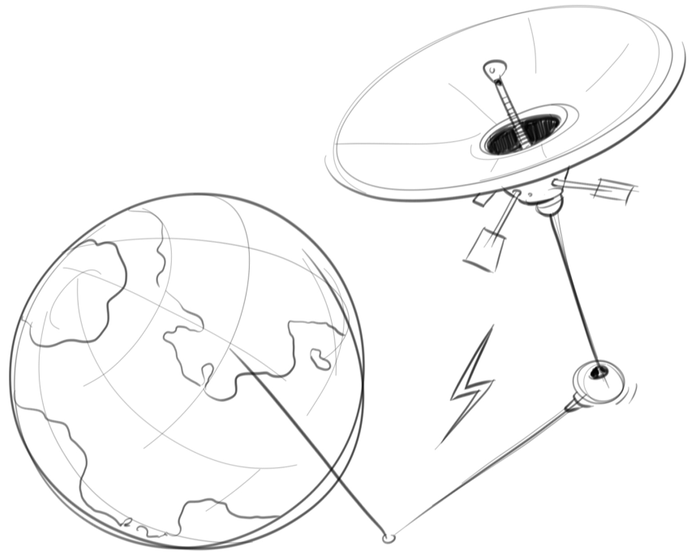
FT15.16. Solving the new fuel poverty in smart homes can only be done by technology. So if you are going to build 500 homes, it is beyond me, why you are not building those 500 homes with rooftop solar, with battery storage, and a DC grid. It is not that expensive and will save these people from fuel poverty. In the renovation of old homes also technologies exist, right now, to solve this. Today huge amount of energy are consumed in data centres. If you can convince a corporate company to disaggregate its computing power, so all that back office processing that is happening. There is companies today, one installs it in a water heater, the other one mounts power computers onto a block of aluminium. That 20 kilogram block of aluminium is a radiator. Install it in your home, it manages the energy you use and gets that money back. It just stands there, it is a nice heat, because it doesn't get red hot and cool down, and it just sits there heating the room. Free of charge.

FT12.05 ... The grid for transmission over longer distances will always be a huge investment that can only be done on a high level. But if it comes to micro-grids, where people can simply come together as twenty houses to become more or less grid-independent. It is possible and I hope it will happen. This will change the way people see energy. Now energy is something that comes out of a plug, and it is unfortunate that we need to pay for it at the end of the month. But then it will be also become a game: how can I tweak my system? There will be a play-component that is more rewarding.

FT23.07 ... So I think this is the future: to help the local entrepreneur with money of the government to support investments to make a new generation of social housing. Until now social housing was poor buildings for poor people. This is a disaster. No service, and most social problems in big cities comes from this policy. Give the ghetto's' good infrastructure, improve their liveability, give these people a better life.

Applying new technologies

In 2050, a range of new technologies are available and affordable. Some of them are already in development, others are still unknown. Cities apply those technologies in new solutions that contribute to the quality of life, and in particular to the creation of smart buildings, smart mobility and smart urban spaces.



This Driver for Change represents the following cluster of quotes of the thought leaders:

a. Applying new technological solutions to increase quality of life in cities

FT7.17. There is another trend that is now not included: in 2050 humanity has moved into space. We will have much more activity in space, on the moon, on asteroids. ... When we succeed to harvest energy in space and beam it to earth it will be a revolution.

FT2.15. We will have our first test satellite up with solar power in 2017. We might be able to have the worlds first beaming of solar energy from space.

FT5.01. In 2050 I imagine that they are looking for the new world in space, out of our world. ...and maybe, if we will create a much better world than this one, there will be no-one left on this planet.

FT8.11. ...Technology will make diseases extinct. ... To be honest I do not know how feasible this is by 2050, surely aids, maybe not distinct, but under control. But if the key could be unlocked, for cancer for instance, I think this would have a huge impact on people's lives. Also because we will be getting older, so the more that you can cut out these kind of things would contribute to premature deaths, but also having an impact on the quality of live ...

FT10.13. ... I am not saying that by 2050 we will have an infinite amount of energy, but we will have so much that we can consider things like the 'beam-me-up-Scotty' type of stuff or space travelling.

FT5.07. ... Technology will enter all kinds of fields and disciplines, so this will happen everywhere.

FT2.12. Maybe the sweet spot is fabrication in the city, in vertical farms or whatever, 3D printing food. If I want a cup of coffee, I'll print the cup. The table will be a 3D printer, printing up my cup. One of the divisions in Carnegie University has a project on programmable matter. At the moment they are little units, but their idea is to have them at micrometre scale, where the particles are basically magnets, they change colour, they've got behavioural autonomy and swarm collective intelligence. It is basically very fine dust that can take form and shapes and lock into. It may sound as fantasy now, but this sort of thing will be there in 2050. ...

FT15.06. Today all buildings have an AC grid (alternating current), some today have a DC grid (direct current). By 2050 there will be DC grids. The majority of the assets in the buildings will be DC.

Flexible ‘re-purposing’

In 2050, we’ve adapted to continuous city dynamics. Buildings are part of the constant transformation of urban area. People know that ‘things are always changing’, so they have an open mind on how buildings and spaces are used. So this can change over time - or even during the day – in line with changing needs and events. As properties become available, they are used for meet the specific need at that time. Individuals and smaller collectives with shared interest have easy access to available properties, sites and services. Historic buildings and cultural heritage are ‘re-purposed’, taking their specific qualities into account.

This Driver for Change represents the following clusters of quotes of the thought leaders:

a. Re-purposing as part of urban planning
b. Different use of spaces in time

FT4.03 … If we are going to a situation that is much more balancing between autonomous, cooperative, collective initiatives which are related to each other in a decentralised way, then I think that will have tremendous impact on how we try to manage that. Far more decentralised, semi-autarchic systems then the old hierarchical one. … At the moment you see a lot of examples of temporarily use of spaces and buildings, which is trying to fit into temporary needs of small collectives of local stakeholders or shareholders. That is clear evidence of it. And the increasing popularity of it and it also fits perfectly in this evolutionary idea, because it is not so much anymore about making a blue print plan, it is much more about ‘go with the flow’, or floating on the local flows, and let things grow. That does not mean that these temporary things come, go and there is nothing, they can grow, flower up, go through phases and increasingly becoming richer or more mature, a study for local and area development where we can play and experiment, of which we can learn.

FT14.05. I think that we will face changes in the commercial sector and commercial buildings too. Shopping changes. We will shop quite a lot in advance, and online. Commercial buildings will become more like museums, or galleries, where products can be touched and seen. But necessarily being shopped anymore. So maybe department stores are becoming more similar spaces as museums are now. Which they probably are already today, but they do not yet acknowledge it. I think in Europe we are still not online enough to skip the purchasing part. That is why I think these environments are still run in an old-fashioned business model.

FT17.09. The idea of work, entertainment, life will blur totally. Also having access to computers everywhere: you are learning all the time, and you are probably working all the time and entertaining all the time. There is no need to having the 8-hour shifts. The concept of time will change. This is more abstract, and more difficult. It will be more like a spiral. Now we have linear economy, some people are talking about a circular economy, but I believe we will have to think in spiral terms. We are moving forward, while revising and iterating.

FT25.03. Coming back to buildings, they will naturally progress, but I don’t see that is an area of huge innovation. We’ll learn to build around these new cycles, so it is more an issue of understanding the life cycle of the occupants.

Enabling human development

In 2050, city residents are resilient, and can consciously adapt their behaviour to enable personal development. The middle class have largely disappeared. People have found new ways to live meaningful lives, building on opportunities at all levels – from local to global. They can handle large amounts of information to make personal choices. Smart, human-centric city environments provide inspiring places for lifelong learning.

This Driver for Change represents the following clusters of quotes of the thought leaders:

a. Enjoying a meaningful life
b. Ongoing learning and personal development
c. Resilient people
d. Personalised solutions enabling to rethink your behaviour
e. Making personal choices in the context of too much data

FT8.15. ... And you actually have more free time. And that means that you then have to think about what else you can do in that free time. ... So maybe there is a much more modern perception of what is work like verses personal life. And personal life may also include that you are in the governing board of your school, or your cities water production, or solar panel installation group, but that is not considered your work, that is just how you spend your time.

FT22.04. It is very important to give the next generation access to all the knowledge and all the technologies. But also to teach the importance of how to live in the urban society. ... It is important to manage all this in the right way.

FT8.16. There will be a need by 2050 to develop not only resilient infrastructure but also resilient civilians to overcome natural disasters. ... That there will be more and more dramatic environmental events. And they will have a real impact on very predictable cities and countries. Not only flooding, but also fires, extreme temperature, and I think that in that sense every city will be vulnerable. ... You need built an infrastructure for the city that is protected from that. But you also need to build civilians that are able to have that resilience, that are able to "yep, this is coming, this is what we need to do, we'll move on and if something happens, which will, then we have the means to deal with it and we will move forward." ... the civilians are actually able to plan for that complexity. They understand that they cannot control everything and they can just manage the effects. And they know that they can do that.

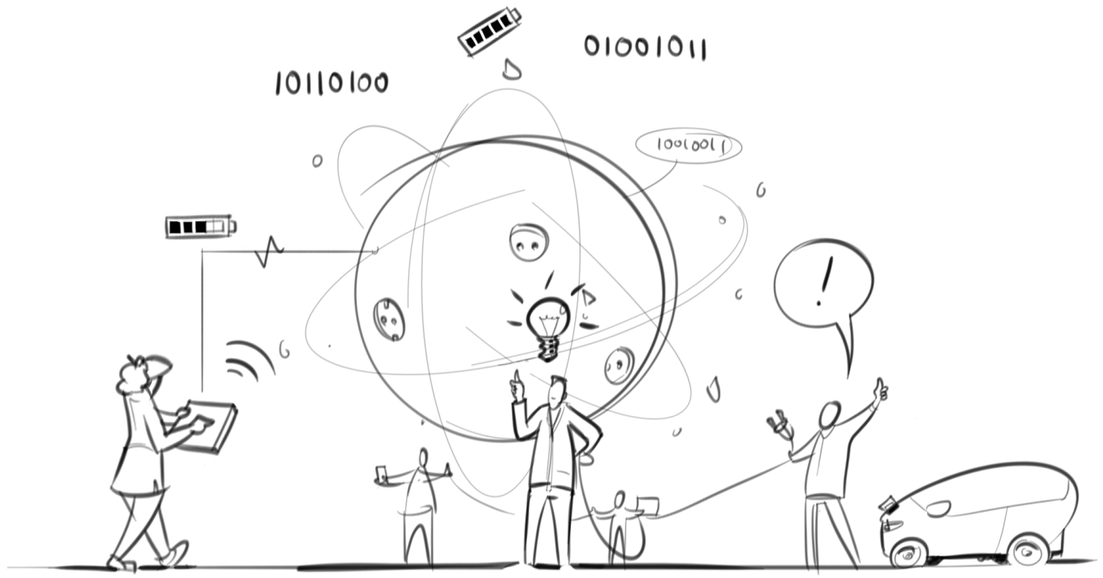
FT9.07. ... So the new generation has to optimise their resources and have to learn about the consequences.

FT15.10. How people cope with that will be another question. Today already, let's call it the younger generation, have modified how they take in information, where you and I used to read things from paper, from page one all the way to the end. That will never happen again. The contextual information that you come across, has to be in 150 characters. But that already changed us.

FT9.10. Our behaviour is driven by facts. All this data is definitely defining our choices. What we see on Facebook and Instagram, it has a big, big, big influence on our choices. Our choices are now defined by these kind of social networks.... these networks are easy. And that is even going to be much more useful for the next generation.

Democratised energy systems based on open data

In 2050, energy systems are open, bidirectional, multi-purpose platforms on which (renewable) energy and energy management services are open to all. Entrepreneurs have developed business models that provide value for them, for their users and for society at large. Citizens can choose freely from a range of available options. The system ensures privacy and security of users, who are always in control. Ambient energy networks provide connectivity for (wireless) access to data and energy. Increased computing power and artificial intelligence make system resilient: self-organising, self-sustaining and self-learning.



This Driver for Change represents the following clusters of quotes of the thought leaders:

a. Open infrastructures to bring together supply and demand of energy in decentralised systems
b. Privacy and security in systems and services build on open data
c. Being in control with or being controlled by intelligent systems
d. Merging brain power and computer power to make smarter decisions
e. Integrating (wireless) data and ambient energy networks

FT3.10. There may be a competition of energy networks. Also there will be an integration of data and energy networks. But it could also be a completely new energy internet that is competing with the existing systems.

FT3.09. In cities you will need some sort of layered structure, in which you have a grid that provides stability and interconnectivity, and on top of that you will have more freedom and less restrictions to design your own thing. It will affect the city as it will no longer be needed to have global or national grid that is build by a government. But there will be local grids that provide enough stability by sharing resources so that you have a guaranteed stable energy production in the way you want it. You need to ensure that everybody can connect to such a grid, but it will be more local grids, that do not necessary need interaction. ...

FT19.04 ... One of the other things in district heating now is that the one who owns the network is also the one who provides the service. It is like a monopoly. You cannot choose. We need a new type of district heating - open. Not only to increase the investment capacity, but also for everybody to be able to put heat on the network. So that you have a distinction between the network infrastructure and the heat generation capacity. Because in the city there are a lot of heat sources, e.g. industries, data centres. They produce a lot of heat and this can be used to heat buildings. So you need this openness, like for electricity.

FT19.06. The other important value is openness. The way I described it, the way we organise it has to be open. Technology is available, but what kind of openness do we want? By getting this openness you get a new form democracy. ...

FT13.35. Data is the fuel of the 21st century. ...

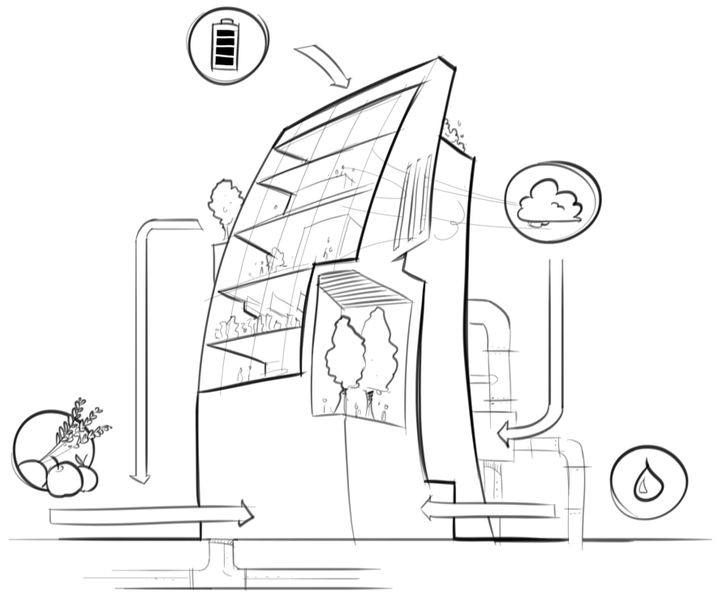
FT16.03. ... the fact that people do not need energy, but they need to wash, to cook, to be warm. The fact that they will be able to produce energy directly, or coming from their neighbour. And the fact that digital technology will allow to combine this supply and demand, I will guarantee that all activity will move from energy producer and energy distributor towards energy manager. ...

FT1.06. Analysing and monitoring our human systems on the social level, in public spaces or in social contexts, we will have a lot of new conditions which we do not know up till now. Next to an impact on humanity, it means that we have to redefine what is life and what is public and what are our civil rights. ...

FT10.14. ... I think in 35 years, when we really get this wisdom of the crowd, and let the crowd of humans, robots or together decide. You cannot really draw a line between humans and robots and you can't actually soon draw a line between a human and computer. ...

Regenerating resources in a circular economy

In 2050, the circular economy ensures self-sufficiency of cities. Renewable energy is abundant, and this ensures a secure supply of vital resources for life (energy, water, food and clean air), although other resources may still be scarce. Cities have implemented circular systems to regenerate all the resources needed by their populations. These mechanisms are based on small-scale, local solutions, enabled by changed decision-making levels.



This Driver for Change represents the following clusters of quotes of the thought leaders:

a. Self-sufficiency based on an abundance of renewable sources and storage solutions
b. Regenerative cities with circular systems for all relevant resources
c. Securing supply of food, water & clean air

FT3.08. Abundance of energy is really foreseeable in the future, also of other resources, maybe even water. We will have energy producing houses, energy producing green houses, energy producing cars with solar rooftops etc. This will have a big impact.

FT16.13. I see the development of renewable energy too. Not only in generation, but also in biogas. We have made some analysis and we think if we can produce biogas from 100% of the green waste in a city being from homes, from schools, from restaurants, from city gardening, from supermarkets, we are able to produce enough biogas to feed all the buses and all the waste collecting trucks with that. It is still expenses, and now more expensive than filling them with fuel. So as long as we accept the emissions, nothing will change, but in the end we have to. ...

FT15.1. In the not too distant future, so by 2050 we'll have a scenario where there will probably be four commodities as we will see it. Nowadays we've got electricity, gas and water. I think air quality will become something we have to pay for. One of these days we will have to pay for clean air.

FT24.01 We do everything to bring renewable energy better into the grid, by using smart grid technology.... As soon as we have this abundance of energy – either renewable energy or nuclear fusion for example – then we still need a smart grid to put the energy to the grid, but we don't need to worry about saving energy by all means. ...

FT21.14. My vision for a city, for the 'ecopolis', or the regenerative city, is a city that basically has all mechanisms to regenerate the resources that are absorbed by the people who live in the city. Be it the materials, the food, be it the energy, the air that they breathe. And if this principle of regeneration becomes the guiding principle for designing cities, then we will come to this ecopolis. Where you have lots of green spaces to regenerate the air. Maybe some kind of urban farming places. Maybe we see skyscrapers that are not just for offices that remain empty, but that have some kind of food production, that host people, and that are some kind of a sustainable system in themselves, generating the energy. It is actually a very liveable place.

FT17.06. The new game-changing technologies will be more probably in the field of materials. It will totally change the way we make things, and the way we actually can reuse the material. ... It will be more like material engineering, things can be programmed, there is no trash, because you can reprogram the material and turn a computer into a car, just with new code. ...

FT21.4. Major issues, like food, production and water supply are regulated and organised on a global scale. That is already relevant now, but it is definitely one of the future trends. ...

FT21.19. For water I give a concrete example. It is about regenerating the resources. If you look how in some cities water and sewage is treated, ... Treating our sewage or water system in a way that regenerates the resources and nutrition makes a lot of sense to me. ... It is an important factor to start to separate those immediately to be in a position to much easier reuse it, than it gets all mixed up in what we call black water. I think that is still on a very low developed level unfortunately. We had somebody in our expert group, who has proposals for the separation of our sewage and regaining nutrition and bring them back to the agricultural system. That makes a lot of sense when it comes to regeneration. ...

SMART BUILDINGS

Newcastle City Council

ENERGY SMART BUILDINGS AND INFRASTRUCTURES ENABLING A HIGH QUALITY OF LIFE AND THRIVING ECONOMY IN NEWCASTLE 2050

In 2050, people in Newcastle enjoy energy-efficient buildings with a high level of comfort. All homes and non-domestic buildings are connected to an effective energy system, to achieve net-zero energy consumption and net-zero emission.

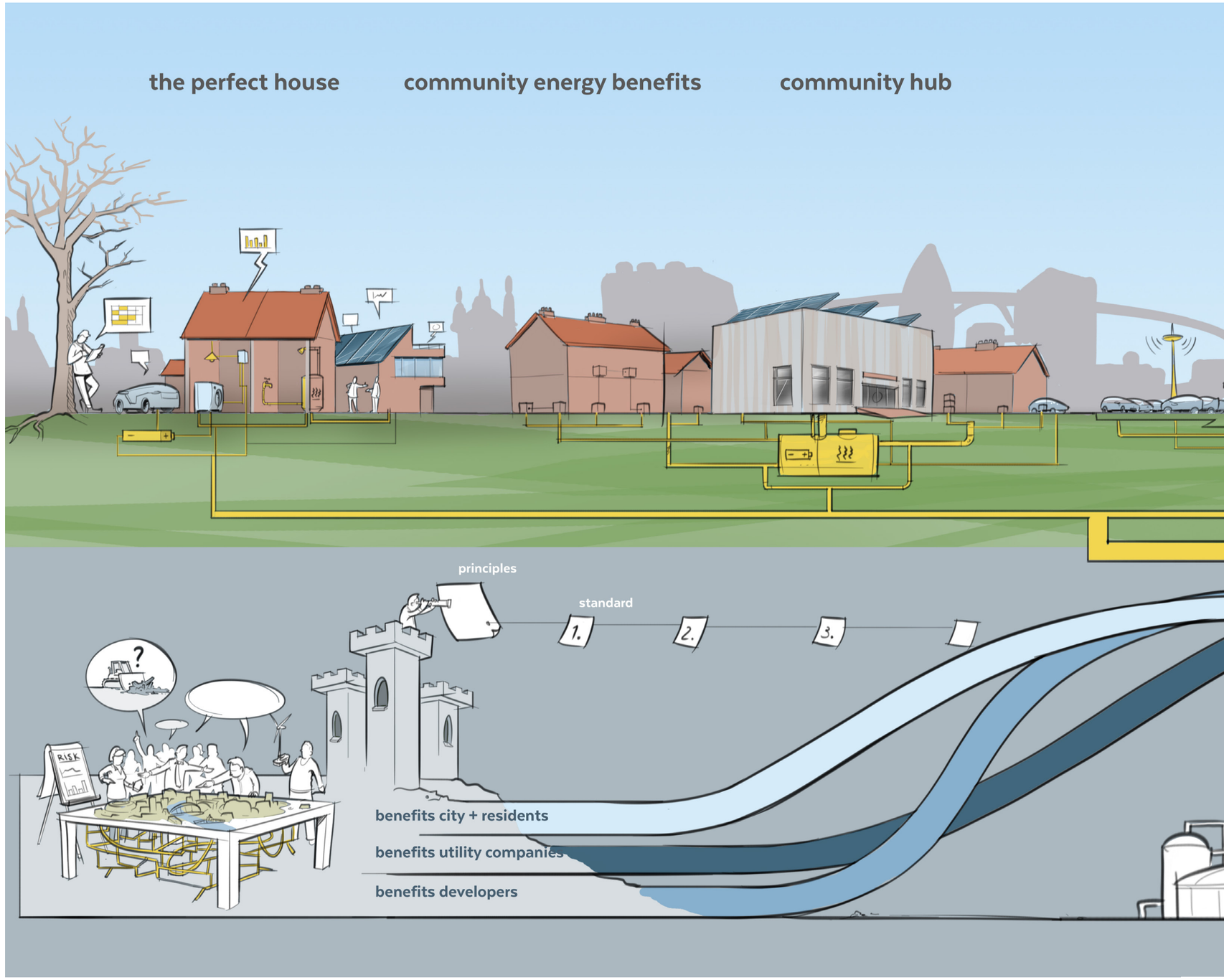
Newcastle has adopted a collective approach to decisions in the infrastructure that enables joint decision-making with stakeholders in the city. Urban planning takes a broad wide-area view to take full advantages of the opportunities extending beyond site or estate boundaries and city limits. Through the open data centre the City Council and its partners are able to implement evidence-based policies and decision-making. Residents are empowered and have the means and the wish to make responsible choices on their own energy usage and investments.

Sustainable buildings

Homes and non-domestic buildings provide high levels of comfort with sustainable energy solutions. They support their users with personalised advice to save energy in line with their lifestyles. Retrofit solutions as well as new innovative buildings ensure that all buildings are sustainable. Buildings are exemplary in their use of innovative and sustainable technologies. High visibility of the solutions supports their adoption as well as a thriving building sector that 'exports' design and consulting services. In this way the standard of the buildings is raised, adding value to existing business models in the local community.

Smart infrastructures

Infrastructure interconnects local grids for different energy sources, such as electricity, temperature control (heating and cooling), water and data, and connect the local grids to regional and national levels. Local grids enable communities to invest in and share sustainable solutions with peers, and support optimal use of renewable energy and the specific features and qualities of separate buildings. All buildings are connected to the grid, receiving and transmitting information to peers or to a wider network with respect for the privacy of the users.



The top layer of the visual represents different type of buildings and sharing options, with an increasing complexity of the solutions. This builds up from a (perfect) house, connected within the neighbourhood, through a community hub around a (public) building, shared use and modular buildings, right up to the future living environment.

At the bottom left the new policy and planning process are shown as a way to manage future-proofing. Elements of the desired future scenario here are the flow of benefits between stakeholders, and city-wide planning (around the table) to align information and decision-making.

At the right of the visual are the underlying infrastructure and personal schemes, which are needed to enable all the other solutions.

Version 15 June 2016

Flow of benefits

An integrated planning and development process optimises the flow of benefits for different stakeholders. The value of 'community gain' is considered (not just financial gain) is considered through local integration. A long-term perspective allows business models and decision making to consider state-of-the-art solutions and to avoid the need for renovation. Democratic decision-making enables future retrofitting with participation by residents.

City-wide planning

Policy-making and planning in Newcastle are based on a city-wide plan. This fully integrates all assets and their interactions, so the total impact on the surrounding can be considered. A collaborative approach together with all stakeholders drives alignment of information and leads to better decisions. Through regional cooperation, one set of principles provides developers with progressive standards to achieve sustainable projects.

The perfect house

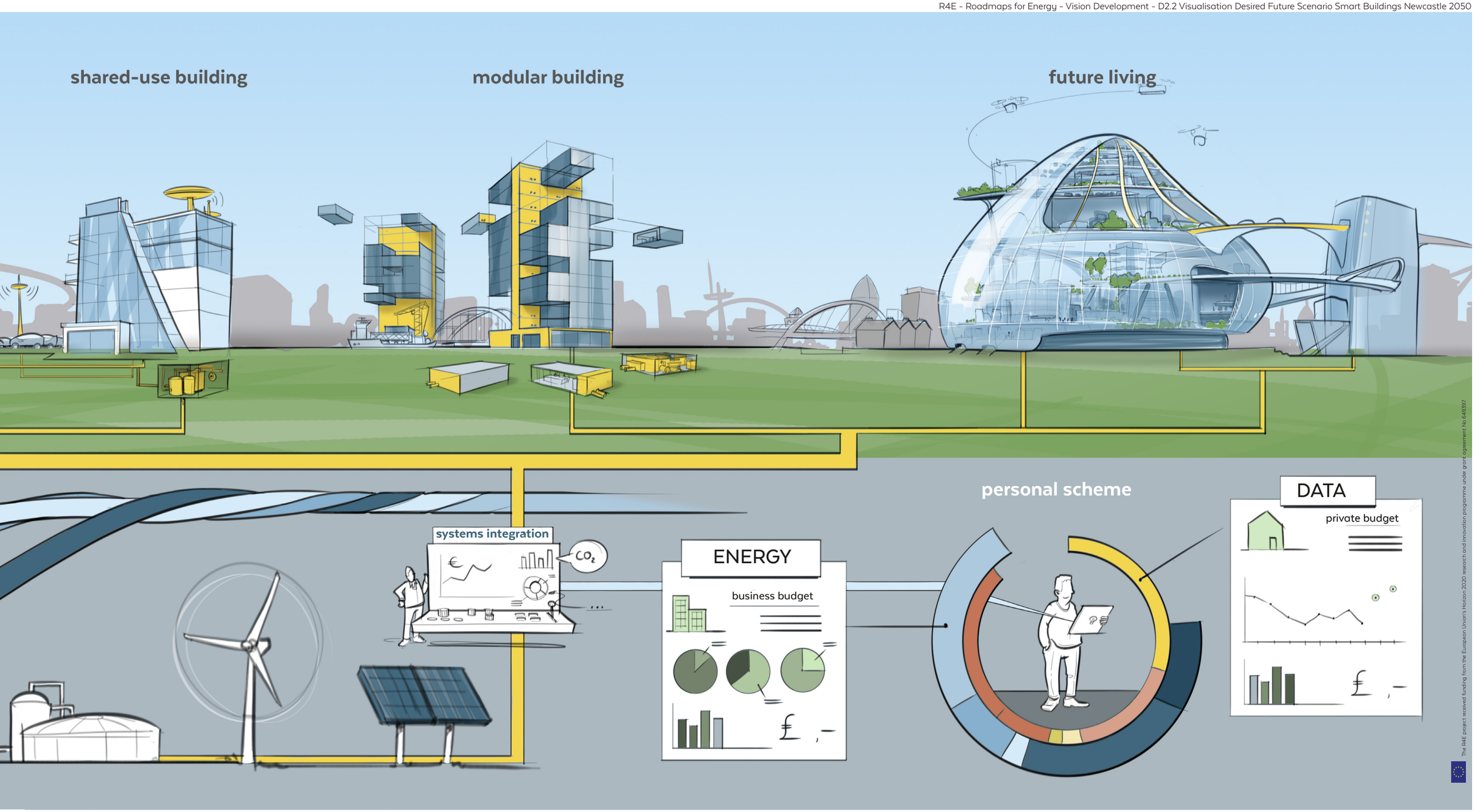
Houses are designed for people. Connectivity with the energy and data net provides valuable services for comfortable living (e.g. tele-care). People can make responsible choices, even from options they did not think of themselves. The smart house manages itself according to set parameters. Simplicity and accessibility are the norm: people have freedom of choice, with full control oftheir homes and their lives.

Community energy benefits

People living in Newcastle's estates jointly benefit from shared sustainable resources provided through local grid solutions. Residents share energy solutions tailored to their homes (e.g. PV panels on south-facing roofs, or turbines in 'windy gardens', with basement for batteries). The grid provides local interconnectivity promoting community-building and cultural change.

LIGHT HOUSE / expertise in smart lighting & smart cities @ TU/e

R4E ROADMAPS FOR ENERGY®



The R4E project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649397

Community hubs

Residents, businesses and public organisations share energy through a two-way interactive local grid. This increases resilience, benefitting from the strengths of the features and investments in other buildings. The benefits of energy investments and production are retained within the community. A smart (virtual) infrastructure allows matching of fluctuations in energy supply and demand of energy.

Shared-use buildings

Smart (wireless) systems enable flexible use of buildings with variable occupancy patterns and users' needs. Office buildings, shopping centres, community buildings and schools can meet varying demands for space by providing the required energy, lighting and heating according to specific user and activity profiles. The building minimises energy consumption by recognising recurring patterns of use.

Modular buildings

Modular buildings offer smart systems, increasing flexibility for reconfiguration of spaces and energy systems (biomass boilers, heat pumps, PV modules). Smart building controls enable internal restructuring. Flexibility de-risks the business case for investors to make the building structures future-proof. Newcastle can exploit its heritage of building large ships and offshore structures to develop core structures that can be clad with modules.

Future living

Citizens' daily living patters have changed significantly. Buildings suit the activities of future citizens, with flexibility between working, living and leisure activities. Future buildings offer a range of facilities and technologies to encourage social interaction.

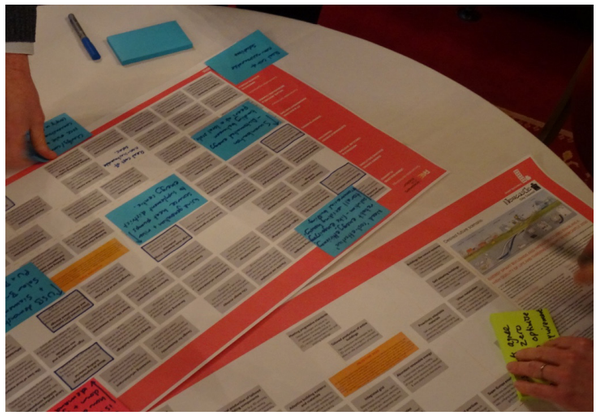
Personal energy schemes

Individual energy schemes with personal roaming profiles allow the use of (wireless) energy and data where and when they are needed. These provide access to new services such as telecare or energy donations. The scheme enables localised trading, sharing and lending of resources through peer-to-peer networks. The scheme addresses different lifestyles and provides individual budgets and advice for behaviour based on planned and predicted usage.

Energy infrastructure

The energy infrastructure enables gradual replacement of non-sustainable energy sources by renewable energy in buildings as well as regionally (e.g. wind parks and solar farms). Optimisations are done at the appropriate levels, linking local, regional and national grids. Shared data and knowledge from all stakeholders feed into the city-wide plan and support future-proof decision-making. In 2050, Newcastle is a net-zero emissions city.

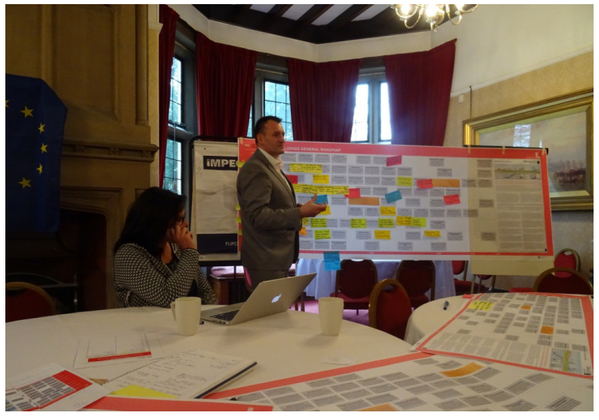













ROADMAPPING

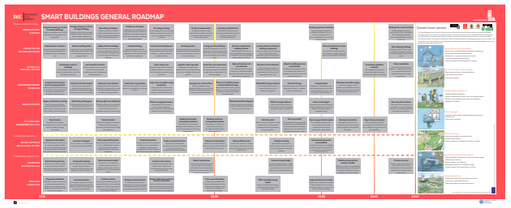
SMART BUILDINGS

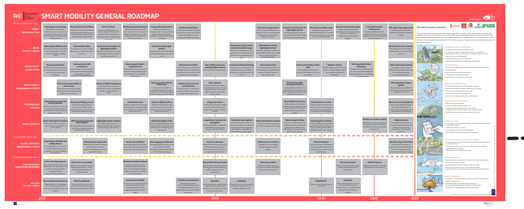
Roadmapping

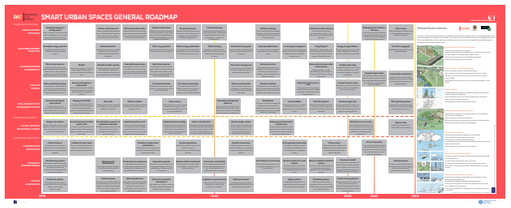
The aim of Step 3 is to develop specific roadmaps for the cities in the selected focus areas. A roadmap shows all existing and future technologies and other relevant developments that enable the achievement of the desired future scenarios by 2050. Two main activities take place in this step. Firstly, the roadmapping research to define the general roadmaps. Secondly, the definition of milestones for the years 2020 and 2030, and local solutions and research projects to create city-specific roadmaps.

General roadmaps

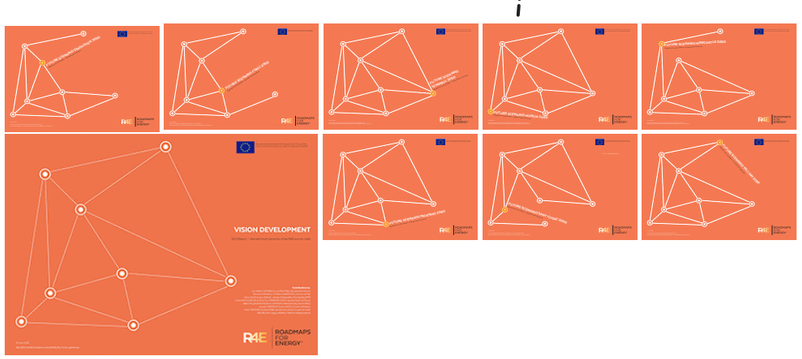
Desk studies and expert interviews are conducted to collect input for the roadmaps. The roadmaps explore the options to achieve the cities' desired future scenarios. The resulting General Roadmaps for Smart Buildings, Smart Mobility and Smart Urban Spaces provide input for the city-specific roadmaps.







Smart Buildings General Roadmap - D3.2 report,
Smart Mobility General Roadmap - D4.2 report,
Smart Urban Spaces General Roadmap - D5.2 report



Vision Development - D2.2 report - Desired future scenarios of the R4E partner cities

Roadmap Workshops

The city-specific roadmaps are created in a series of workshops held in each of the partner cities. These Roadmap Workshops consist of programmes with three sessions in each city.

In the first session, the policy-makers and city representatives select the topics from the general roadmaps as focus for the city-specific roadmap. This choice is based on their specific ambitions and context. They also define intermediate milestones for 2020 and 2030 on the path to their desired future scenarios.

Then, for each of the focus areas, local stakeholders (companies, citizens, public and private organisations and knowledge institutes) are invited to take part in the roadmapping sessions. With all the available knowledge of potential developments and the given focus of the city, the local stakeholders generate project proposals for (local) solutions and research proposals, as a first step towards the project portfolio. See also the pictures of the workshops on the previous page.

The results of the Roadmap Workshops are reported in the same format for each of the cities, facilitating cross-learning between the cities.

City roadmap workshops	Focus and milestones	Focus area 1	Focus area 2
	Making choices for the focus and intermediate milestones in the city specific roadmap to realise the Desired Future Scenarios for the two focus areas.	**Completing the roadmap** • Identifying (local) solutions and research projects needed to reach the city's desired future scenario • Reflecting on results and identifying missing solutions and research projects	**Completing the roadmap** • Identifying (local) solutions and research projects needed to reach the city's desired future scenario • Reflecting on results and identifying missing solutions and research projects

Programme of the roadmap workshops in the cities

Joint Roadmap Workshop

In a joint meeting in Newcastle, the cities presented their city-specific roadmap enriched with current projects and proposals for new projects, and held in-depth discussions to understand the common and specific learning objectives and opportunities for joint projects. The Joint Roadmap Workshop served two purposes:

- To enable cross-city learning. The cities gain a deeper understanding of the roadmapping process, and can improve their own roadmaps with inspiration from others.
- To describe the common learning ambitions as input for the Project Portfolio step.

The Joint Roadmap Workshop finalised the activities of Step 3 and prepared for Step 4, in which the project portfolio will be further developed.

Day 1 Finalising Step 3	Learning from each other • Presentation of current projects and proposals for new projects • Gaining understanding of the current strengths and challenges of the R4E partner cities
Day 2 Preparing for Step 4	Identifying cross-city learning objectives • Selecting common ambitions • Formulating cross-city learning objectives as input for the Project Portfolio step

Programme of the Joint Roadmap Workshop

Newcastle City Council

How to read the general roadmap

The resulting General Roadmap contains four important elements:

- The timeline from now (2016) to the visions for 2050 as described in the desired future scenarios of the cities (see D2.2 — Report Vision Development for the full set of desired future scenarios).
- The eight common needs in the desired future scenarios as described by the cities in the Joint Vision Workshop (see also D2.2) are indicated at the end of the timeline in 2050 as the goal of the roadmap.
- The relevant topics for the focus area on which developments are required to achieve the desired future scenarios. These topics cover sustainable technologies, sustainable behaviour and sustainable organisations.
- The options that will become available in the short or longer term for each of the topics.

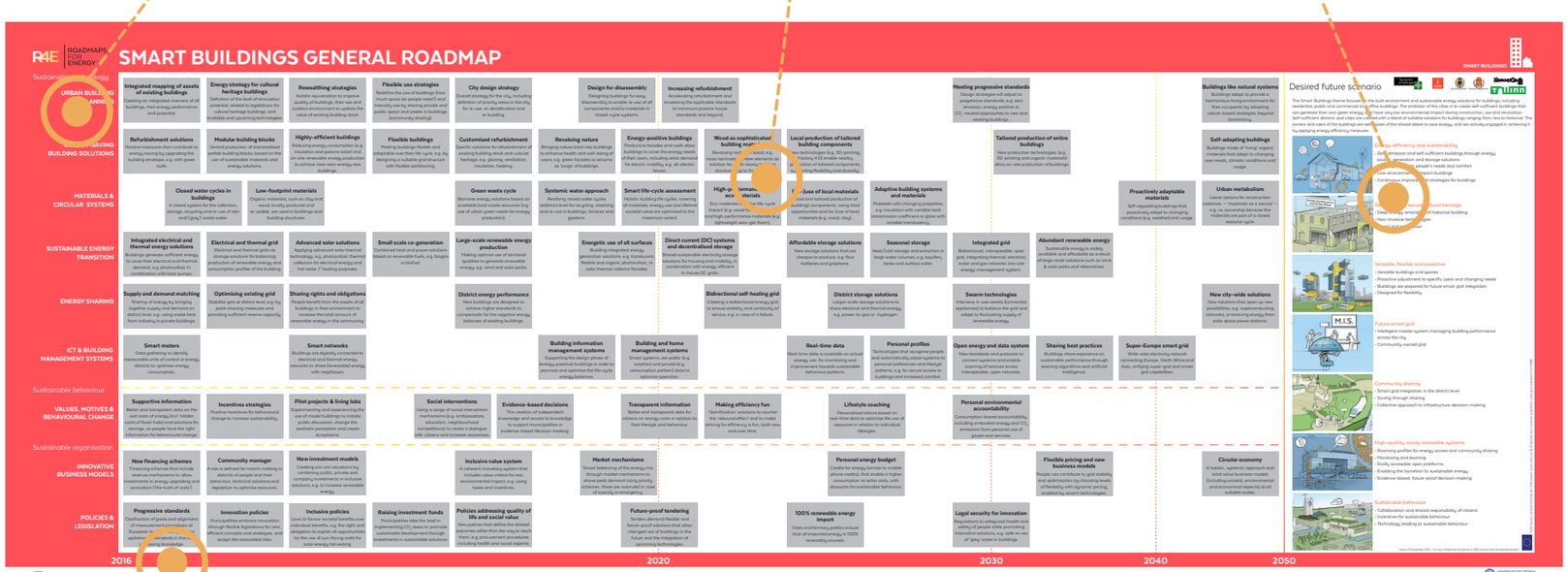
Each topic has a timeline showing the developments that are relevant to that topic.

The image shows the elements of the General Roadmap.

Relevant topics for the focus area

Future options on the timeline

Common needs in the desired future scenarios for 2050



Timeline from now (2016) to the vision (2050)

Elements of the Smart Buildings General Roadmap

Relevant topics Smart Buildings

SMART BUILDINGS

The generic roadmap shows timelines for the topics requiring developments to achieve the desired future scenario in 2050. The selected topics for the Roadmap Smart Buildings are described briefly here.

Sustainable technologies

The first element needed to achieve the sustainable energy ambitions is the availability of sustainable technologies. A wide range of sustainable technologies is already available, and new technologies are constantly being developed. But unfortunately there is not always a consensus on the best option for the future. The Roadmap Smart Buildings includes the following technology developments:

URBAN BUILDING PLANNING

Urban Building Planning is about a structured approach to buildings within the overall city planning strategy. This topic refers to the need for integrated mapping of existing assets on a city-wide scale in developing holistic use and refurbishment strategies. This includes strategies for cultural heritage buildings and the introduction of progressive building standards, as well as developments towards the use of closed-cycle systems.

ENERGY-SAVING BUILDING SOLUTIONS

Energy-Saving Building Solutions refers to materials, systems and strategies to reduce the energy needed for the construction, operation and lifetime maintenance of the building. This includes strategies for building materials and systems, as well as flexible and adaptable energy-savings concepts. It also refers to the way buildings and their components will be constructed in the future.

MATERIALS & CIRCULAR SYSTEMS

Materials & Circular Systems is about material, water and waste cycles in buildings and their contribution to energy-efficiency and resource savings. The topic refers to the importance on closing material, water and waste cycles of buildings and the use of low-impact materials. This includes how buildings and their materials can be made increasingly adaptive, so they contribute to an urban metabolism based on closed resource cycles.

SUSTAINABLE ENERGY TRANSITION

Sustainable Energy Transition refers to the transformation of energy systems on the scale of building and grid towards integrated renewable-energy solutions. It is about the way current energy systems are becoming increasingly smart and integrated, shifting towards solar based, building-integrated renewable-energy solutions. The topic includes future grid developments for electricity and heat, including storage solutions and integrated management.

ENERGY SHARING

Energy Sharing refers to strategies that make individual buildings into contributors to efficient city-wide solutions. This topic deals with the active future role of buildings in the overall energy system, including supply and demand matching and contributions to improved grid stability. More specifically, this topic is about how to optimise overall district energy performance based on future energy grids.

ICT & BUILDING MANAGEMENT SYSTEMS

ICT & Building Management Systems is about the increasing generation and use of data to manage and optimise energy in buildings and grids. This refers to smart meters and their evolution towards smart networks supported by building information and home management systems. It also includes the increasing availability of real-time data and the interoperability of networks, resulting in improved performance through shared learning.

Sustainable behaviour

One of the crucial elements of a sustainable city is the behaviour of citizens. Making a collective shift to more sustainable solutions and energy-saving alternatives requires awareness. In many cases, the available technologies are not sufficiently attractive to gain acceptance in mass markets. The Roadmap Smart Buildings includes the following behavioural developments:

VALUES, MOTIVES & BEHAVIOURAL CHANGE

Values, Motives & Behavioural Change includes personal and institutional ways to drive transformations by new approaches to information, experience and personal accountability. This includes instruments like incentives, pilot projects and lifestyle coaching, all of which can contribute to evidence-based decision-making and lifestyle changes.

Sustainable organisation

Last but not least, the element of sustainable organisation is addressed. How can we

organise the collaboration between relevant parties (public, private, citizens) to achieve the desired future scenarios? Because the technology is not yet mature, new business models are needed to enable learning processes, and these can be modified and updated as necessary. The Roadmap Smart Buildings includes the following organisational developments:

INNOVATIVE BUSINESS MODELS

Innovative Business Models refers to new financial schemes, investment models and market mechanisms that accompany transition processes or arise as a result of those processes. This also includes new and inclusive value systems, coherent monetary systems and new ways of managing energy at personal and community levels, viewed from societal, environmental and economic perspectives.

POLICIES & LEGISLATION

Policies & Legislation refers to the role of municipalities and the changes in policies, with a holistic focus on improving the quality of life and societal value for the community as a whole. This includes policies and legislations on environmental and energy standards, as well as innovations, public tenders, public investments and taxation to reach the overall political goals.

The city specific roadmap

The general roadmap describes the developments on a timeline, indicating when experts estimate that those development will be broadly available. For the cities to create their specific roadmaps, they were asked to focus on the topics that are most relevant for them to reach their own desired future scenarios. The cities create milestones for 2020 and 2030, describing what they will look like when their own developments and city projects have evolved. In this way each city can indicate the focus and pace that it will need to achieve. Projects can then be proposed on this basis to define (local) solutions or research leading to further realisation of the roadmap.

R4E ROADMAPS FOR ENERGY®

SMART BUILDINGS GENERAL ROADMAP

Sustainable technology

URBAN BUILDING PLANNING

Integrated mapping of assets of existing buildings
Creating an integrated overview of all buildings, their energy performance and potential.

Energy strategy for cultural heritage buildings
Definition of the level of renovation potential, related to legislations for cultural heritage buildings, and available and upcoming technologies.

Rewealthing strategies
Holistic rejuvenation to improve quality of buildings, their use and outdoor environment to update the value of existing building stock.

Flexible use strategies
Redefine the use of buildings (how much space do people need?) and intensify use by sharing private and public space and assets in buildings (community sharing).

City design strategy
Overall strategy for the city, including definition of priority areas in the city for re-use, re-densification and re-building.

Design for disassembly
Designing buildings for easy disassembly to enable re-use of all components and/or materials in closed-cycle systems.

Increasing refurbishment
Accelerating refurbishment and increasing the applicable standards to minimum passive house standards and beyond.

ENERGY-SAVING BUILDING SOLUTIONS

Refurbishment solutions
Passive measures that contribute to energy saving by upgrading the building envelope, e.g. with green roofs.

Modular building blocks
Central production of standardised prefab building blocks, based on the use of sustainable materials and energy solutions.

Highly-efficient buildings
Reducing energy consumption (e.g. insulation and passive solar) and on-site renewable energy production to achieve near-zero-energy new buildings.

Flexible buildings
Making buildings flexible and adaptable over their life cycle, e.g. by designing a suitable grid structure with flexible partitioning.

Customised refurbishment
Specific solutions for refurbishment of existing building stock and cultural heritage, e.g. glazing, ventilation, insulation, heating.

Revaluing nature
Bringing nature back into buildings to enhance health and well-being of users, e.g. green facades or atriums as 'lungs' of buildings.

Energy-positive buildings
Productive facades and roofs allow buildings to cover the energy needs of their users, including extra demand for electric mobility, e.g. all-electric house.

Wood as sophisticated building material
Revaluing technical wood, e.g. cross-laminated timber elements as solution for multi-storey building structures (up to five floors).

MATERIALS & CIRCULAR SYSTEMS

Closed water cycles in buildings
A closed system for the collection, storage, recycling and re-use of rain and ('grey') waste water.

Low-footprint materials
Organic materials, such as clay and wood, locally produced and re-usable, are used in buildings and building structures.

Green waste cycle
Biomass energy solutions based on available local waste resources (e.g. use of urban green waste for energy production).

Systemic water approach
Realising closed water cycles atdistrict level for recycling, retaining and re-use in buildings, terraces and gardens.

Smart life-cycle assessment
Holistic building life cycles, covering all materials, energy use and lifetime societal value are optimised to the maximum extent.

High-performance and eco-materials
Eco-materials with low life-cycle impact (e.g. wood fibre insulation) and high-performance materials (e.g. lightweight aero-gel-foam).

SUSTAINABLE ENERGY TRANSITION

Integrated electrical and thermal energy solutions
Buildings generate sufficient energy to cover their electrical and thermal demand, e.g. photovoltaic in combination with heat pumps.

Electrical and thermal grid
Electrical and thermal grids as storage solutions for balancing production of renewable energy and consumption profiles of the building.

Advanced solar solutions
Applying advanced solar thermal technology, e.g. photovoltaic thermal collectors for electrical energy and hot water / heating purposes.

Small scale co-generation
Combined heat and power solutions based on renewable fuels, e.g. biogas or biofuel.

Large-scale renewable energy production
Making optimal use of territorial qualities to generate renewable energy, e.g. wind and solar parks.

Energetic use of all surfaces
Building integrated energy generation solutions, e.g. translucent, flexible and organic photovoltaic, or solar thermal collector facades.

Direct current (DC) systems and decentralised storage
Shared sustainable electricity storage solutions for housing and mobility, in combination with energy-efficient in-house DC grids.

ENERGY SHARING

Supply and demand matching
Sharing of energy by bringing together supply and demand on district level, e.g. using waste heat from industry in private buildings.

Optimising existing grid
Stabilise grid at district level, e.g. by peak-shaving measures and providing sufficient reserve capacity.

Sharing rights and obligations
People benefit from the assets of all buildings in their environment to increase the total amount of renewable energy in the community.

District energy performance
New buildings are designed to achieve higher standards to compensate for the negative energy balances of existing buildings.

Bidirectional self-healing grid
Creating a bidirectional energy grid to ensure stability and continuity of service, e.g. in case of a failure.

ICT & BUILDING MANAGEMENT SYSTEMS

Smart meters
Data gathering to identify measurable units of control or energy districts to optimise energy consumption.

Smart networks
Buildings are digitally connected to electrical and thermal energy networks to share (renewable) energy with neighbours.

Building information management systems
Supporting the design phase of (energy-positive) buildings in order to promote and optimise the life-cycle energy balances.

Building and home management systems
Smart systems use public (e.g. weather) and private (e.g. consumption pattern) data to optimise operation.

Sustainable behaviour

VALUES, MOTIVES & BEHAVIOURAL CHANGE

Supportive information
Better and transparent data on the real costs of energy (incl. hidden costs of fossil fuels) and solutions for savings, so people have the right information for behavioural change.

Incentives strategies
Positive incentives for behavioural change to increase sustainability.

Pilot projects & living labs
Experimenting and experiencing the use of model buildings to initiate public discussion, change the aesthetic perception and create acceptance.

Social interventions
Using a range of social intervention mechanisms (e.g. ambassadors, education, neighbourhood competitions) to create a dialogue with citizens and increase awareness.

Evidence-based decisions
The creation of independent knowledge and access to knowledge to support municipalities in evidence-based decision-making.

Transparent information
Better and transparent data for citizens on energy costs in relation to their lifestyle and behaviour.

Making efficiency fun
'Gamification' solutions to counter the 'rebound effect' and to make striving for efficiency is fun, both now and over time.

Sustainable organisation

INNOVATIVE BUSINESS MODELS

New financing schemes
Financing schemes that include revenue mechanisms to allow investments in energy upgrading and renovation ('the truth of costs').

Community manager
A role is defined for match-making in districts of people and their behaviour, technical solutions and legislation to optimise resources.

New investment models
Creating win-win situations by combining public, private and company investments in inclusive solutions, e.g. to increase renewable energy.

Inclusive value system
A coherent monetary system that includes value criteria for real environmental impact, e.g. using taxes and incentives.

Market mechanisms
Smart balancing of the energy mix through market mechanisms to shave peak demand using priority schemes; these are overruled in case of scarcity or emergency.

POLICIES & LEGISLATION

Progressive standards
Clarification of goals and alignment of measurement procedures at European level, including regular updating of standards in line with increasing knowledge.

Innovation policies
Municipalities embrace innovation through flexible legislations for new, efficient concepts and strategies, and accept the associated risks.

Inclusive policies
Laws to favour societal benefits over individual benefits, e.g. the right and obligation to exploit all opportunities for the use of sun-facing roofs for solar energy harvesting.

Raising investment funds
Municipalities take the lead in implementing CO_2 taxes to promote sustainable development through investments in sustainable solutions.

Policies addressing quality of life and social value
New policies that define the desired outcomes rather than the way to reach them, e.g. procurement procedures including health and social aspects.

Future-proof tendering
Tenders demand flexible and future-proof solutions that allow changed use of buildings in the future and the integration of upcoming technologies.

2016 — 2020

LIGHT HOUSE

Meeting progressive standards
Design strategies will adjust to progressive standards, e.g. zero emission, energy positive or CO_2-neutral approaches to new and existing buildings.

Buildings like natural systems
Buildings adapt to provide a harmonious living environment for their occupants by adopting nature-based strategies, beyond biomimicry.

Local production of tailored building components
New technologies (e.g. 3D-printing, Factory 4.0) enable nearby production of tailored components, supporting flexibility and diversity.

Tailored production of entire buildings
New production technologies, (e.g. 3D-printing and organic materials) allow on-site production of buildings.

Self-adapting buildings
Buildings made of 'living' organic materials that adapt to changing user needs, climatic conditions and usage.

(Re-)use of local materials
Local and tailored production of buildings components, using local opportunities and (re-)use of local materials (e.g. wood, clay).

Adaptive building systems and materials
Materials with changing properties, e.g. insulation with variable heat transmission coefficient or glass with variable translucency.

Proactively adaptable materials
Self-regulating buildings that proactively adapt to changing conditions (e.g. weather) and usage.

Urban metabolism
Lease options for construction materials — 'materials as a service' — e.g. no ownership because the materials are part of a closed resource cycle.

Affordable storage solutions
New storage solutions that are cheaper to produce, e.g. flow batteries and graphene.

Seasonal storage
Heat/cold storage and extraction in large water volumes, e.g. aquifers, tanks and surface water.

Integrated grid
Bidirectional, interoperable, open grid, integrating thermal, electrical, water and gas networks into one energy-management system.

Abundant renewable energy
Sustainable energy is widely available and affordable as a result of large-scale solutions such as wind & solar parks and alternatives.

District storage solutions
Larger-scale storage solutions to share electrical and thermal energy, e.g. power-to-gas or -hydrogen.

Swarm technologies
Intervene in user assets (connected appliances) to balance the grid and adapt to fluctuating supply of renewable energy.

New city-wide solutions
New solutions that open up new possibilities, e.g. superconducting networks, or receiving energy from solar space power stations.

Real-time data
Real-time data is available on actual energy use, for monitoring and improvement towards sustainable behaviour patterns.

Personal profiles
Technologies that recognise people and automatically adust systems to personal preferences and lifestyle patterns, e.g. for secure access to buildings and increased comfort.

Open energy and data system
New standards and protocols to connect systems and enable roaming of services across interoperable, open networks.

Sharing best practices
Buildings share experience on sustainable performance through learning algorithms and artificial intelligence.

Super-Europe smart grid
Wide-area electricity network connecting Europe, North Africa and Asia, unifying super-grid and smart grid capabilities.

Lifestyle coaching
Personalised advice based on real-time data to optimise the use of resources in relation to individual lifestyles.

Personal environmental accountability
Consumption-based accountability, including embodied energy and CO_2 emissions from personal use of goods and services.

Personal energy budget
Credits for energy (similar to mobile phone credits), that enable a higher consumption at extra costs, with discounts for sustainable behaviour.

Flexible pricing and new business models
People can contribute to grid stability and optimisation by choosing levels of flexibility with dynamic pricing, enabled by swarm technologies.

Circular economy
A holistic, systemic approach and total value business models (including societal, environmental and economical aspects) at all suitable scales.

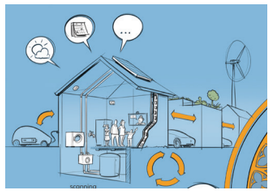
100% renewable energy import
Cities and territory politics ensure that all imported energy is 100% renewably sourced.

Legal security for innovation
Regulations to safeguard health and safety of people while promoting innovative solutions, e.g. safe re-use of 'grey' water in buildings.

2030 2040 2050

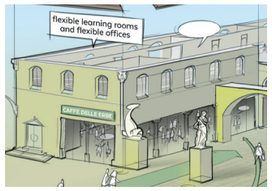
Desired future scenario

The Smart Buildings theme focuses on the built environment and sustainable energy solutions for buildings, including residential, public and commercial and office buildings. The ambition of the cities is to create self-sufficient buildings that can generate their own green energy, and have very low environmental impact during construction, use and renovation. Self-sufficient districts and cities are created with a blend of suitable solutions for buildings ranging from new to historical. The owners and users of the buildings are well-aware of the shared desire to save energy, and are actively engaged in achieving it by applying energy efficiency measures.



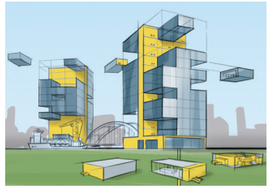
Energy-efficiency and sustainability

- Zero-emission and self-sufficient buildings through energy saving, generation and storage solutions
- Buildings focus on people's needs and comfort
- Low-environmental-impact buildings
- Continuous improvement strategies for buildings



Renovation to secure cultural heritage

- Deep energy renovation of historical building
- Non-invasive technologies
- Smart grid integration

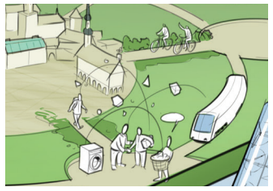


Versatile, flexible and proactive

- Versatile buildings and spaces
- Proactive adjustment to specific users and changing needs
- Buildings are prepared for future smart grid integration
- Designed for flexibility

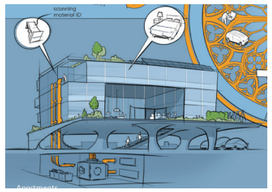
Future smart grid

- Intelligent master system managing building performance across the city
- Community-owned grid



Community sharing

- Smart grid integration in the district level
- Saving through sharing
- Collective approach to infrastructure decision-making



High-quality, easily accessible systems

- Roaming profiles for energy access and community sharing
- Monitoring and learning
- Easily accessible open platforms
- Enabling the transition to sustainable energy
- Evidence-based, future-proof decision-making

Sustainable behaviour

- Collaboration and shared responsibility of citizens
- Incentives for sustainable behaviour
- Technology leading to sustainable behaviour

The R4E project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649397

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URBAN BUILDING PLANNING

- **Integrated mapping of assets of existing buildings** – Creating an integrated overview of all buildings, their energy performance and potential.
- **Energy strategy for cultural heritage buildings** – Definition of the level of renovation potential, related to legislations for cultural heritage buildings, and available and upcoming technologies.
- **Rewealthing strategies** – Holistic rejuvenation to improve quality of buildings, their use and outdoor environment to update the value of existing building stock.
- **Flexible use strategies** – Redefine the use of buildings (how much space do people need?) and intensify use by sharing private and public space and assets in buildings (community sharing).
- **City design strategy** – Overall strategy for the city, including definition of priority areas in the city for re-use, re-densification and re-building.
- **Design for disassembly** – Designing buildings for easy disassembly to enable re-use of all components and/or materials in closed-cycle systems.
- **Increasing refurbishment** – Accelerating refurbishment and increasing the applicable standards to minimum passive house standards and beyond.

ENERGY-SAVING BUILDING SOLUTIONS

- **Refurbishment solutions** – Passive measures that contribute to energy saving by upgrading the building envelope, e.g. with green roofs.
- **Modular building blocks** – Central production of standardised prefab building blocks, based on the use of sustainable materials and energy solutions.
- **Highly-efficient buildings** – Reducing energy consumption (e.g. insulation and passive solar) and on-site renewable energy production to achieve near-zero-energy new buildings.
- **Flexible buildings** – Making buildings flexible and adaptable over their life cycle, e.g. by designing a suitable grid structure with flexible partitioning.
- **Customised refurbishment** – Specific solutions for refurbishment of existing building stock and cultural heritage, e.g. glazing, ventilation, insulation, heating.
- **Revaluing nature** – Bringing nature back into buildings to enhance health and well-being of users, e.g. green facades or atriums as 'lungs' of buildings.
- **Energy-positive buildings** – Productive facades and roofs allow buildings to cover the energy needs of their users, including extra demand for electric mobility, e.g. all-electric house.
- **Wood as sophisticated building material** – Revaluing technical wood, e.g. cross-laminated timber elements as solution for multi-storey building structures (up to five floors).

2016 — **2020**

Urban building planning

Short term developments

- In the short term, integrated mapping of the existing building stock, including its energy performance and the potential for improvement and use support integrated urban planning processes.
- Specific energy strategies for cultural heritage buildings are developed for the refurbishing of historical buildings, incorporating available and upcoming technologies.
- Rewealthing and rejuvenation strategies focus on the quality of internal and external spaces of the existing building stock. This includes the implementation of new and flexible forms of use, as well as sharing of spaces and infrastructure.
- General city design strategies focus on re-use, re-densification and re-building of the existing buildings and public spaces, defining priority areas for intervention.
- A life-cycle approach for buildings is considered, based on design for disassembly and re-use of materials, using closed cycle systems as far as possible.

Mid term developments

- Once experience has been gained and processes and strategies have been developed, the annual building refurbishment rate will be scaled up to 3 to 5% of the existing building stock, from today's typical rate of 1%. The minimum energy standard for refurbished buildings is the 'passive house' standard. However the standards will develop further, with increasing requirements for higher levels such as zero-emission, energy-positive or CO2-neutral performance over lifetime.

Long term developments

- In the long term buildings increasingly adopt nature-based strategies, and are integrated in and adapting to the surrounding natural systems. In this way they offer harmonious living environments for their occupants.

SMART BUILDINGS

Meeting progressive standards
Design strategies will adjust to progressive standards, e.g. zero emission, energy positive or CO_2-neutral approaches to new and existing buildings.

Buildings like natural systems
Buildings adapt to provide a harmonious living environment for their occupants by adopting nature-based strategies, beyond biomimicry.

Local production of tailored building components
New technologies (e.g. 3D-printing, Factory 4.0) enable nearby production of tailored components, supporting flexibility and diversity.

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Buildings made of 'living' organic materials that adapt to changing user needs, climatic conditions and usage.

2030 2040 2050

SMART BUILDINGS

Energy-saving building solutions

Short term developments

- Refurbishment plays a mayor role, and solutions for the upgrading of building envelopes and installations is gaining importance, including on-site renewable energy generation. The aim is to achieve nearly zero-energy standard in new buildings, and where possible also in existing buildings.
- Modular, prefabricated building blocks allow material and energy savings through centralised productions processes, with increasing flexibility and adaptability of buildings over their life-cycles.
- Customised refurbishment solutions for cultural heritage buildings allow improvement of energy performance while also meeting cultural protection standards. Increased energy performance is achieved through higher standards for both new buildings and those surrounding them.

Mid term developments

- Buildings are becoming increasingly energy-efficient and energy-producing, with a development towards energy-positive buildings as standard. Energy-producing facades and roofs cover all users' energy needs, including extra demand for electric mobility.
- Wood is increasingly used as a sophisticated building material, even for structural purposes in multi-storey buildings.
- Buildings are based on customised local building components, which are produced by new technologies such as 3D printing or Factory 4.0 solutions, enabling greater flexibility and diversity.

Long term developments

- Entire buildings are produced decentrally and on-site using new production technologies such as 3D printing and with local organic materials.
- Self-adapting buildings based on 'living' organic materials can adapt to changing user needs, climate conditions and usage.

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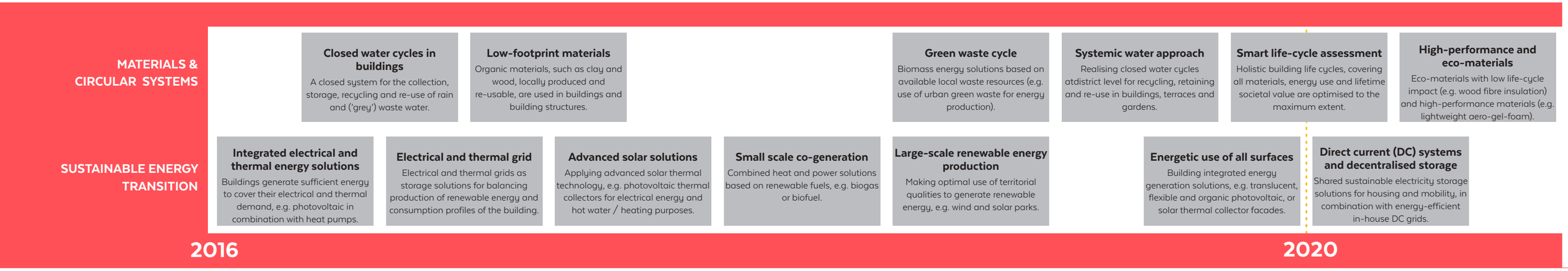


Materials & circular systems

Short term developments

- In the short term water is considered as an increasingly valuable resource, and water cycles in buildings will be closed as far as possible.
- Closed water cycles at district level connect buildings, terraces and gardens to systems for water retention, storage and re-use.
- Building work increasingly uses organic materials such as clay and wood. These are locally produced and re-usable, reducing the overall carbon footprint of constructions.
- Biomass energy solutions use urban green waste for energy production, closing green waste cycles.

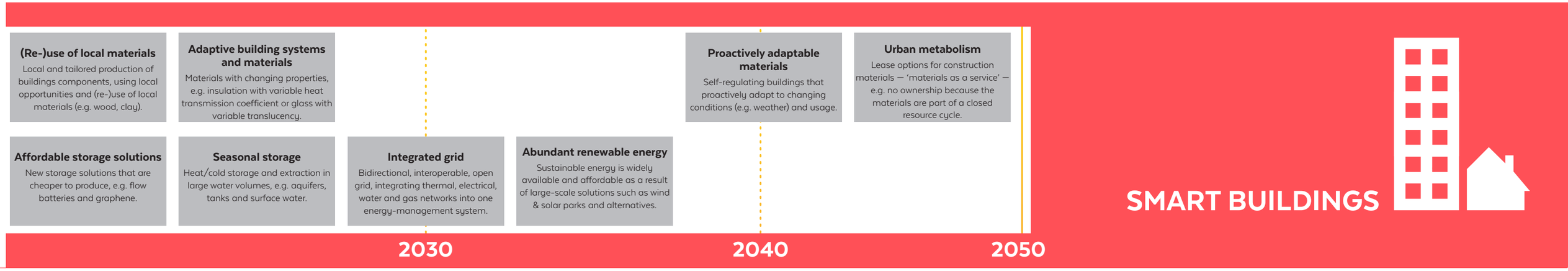
Mid term developments

- In the mid-term, smart life-cycle assessment allows calculation, tracking and optimising of material life cycles, energy use and even societal value of buildings over their lifetime.
- High-performance materials and eco-materials with a very low lifecycle impact are standard in buildings.
- Materials and components are locally produced through tailored production processes based on the (re-)use of locally available resources.
- Adaptive building systems and materials with changing properties are available, optimising the thermal performance of building envelopes.

Long term developments

- In the long term buildings are self-regulating, with materials and systems that proactively adapt to different climatic conditions or usage.
- Buildings contribute to an urban metabolism based on closed resource cycles, understanding materials as a service.

SMART BUILDINGS



Sustainable energy transition

Short term developments

- In the short term, buildings generate enough energy to meet their own energy demand through integrated electrical and thermal energy solutions based on renewable energy.
- Electrical and thermal grids evolve, allowing storage of decentralised renewable energy produced by buildings, as well as balancing of supply and demand.
- Renewable energy technologies evolve towards more efficient and sophisticated integrated systems, e.g. advanced solar solutions such as photovoltaic thermal collectors for building integration or small-scale co-generation power solutions based on renewable fuels such as biogas or biofuel.
- Large-scale renewable energy installations such as wind and solar parks are used widely throughout the territory.
- All available exterior building surfaces are used to harvest solar energy through integrated energy solutions such as flexible and translucent photovoltaic or thermal collector facades.

Mid term developments

- In the mid-term, direct current (DC) systems allow the use of PV electricity through energy-efficient in-house grids, together with increasing amount of shared sustainable electricity storage solutions on all scales for buildings and mobility.
- Energy storage systems are increasingly affordable through the use of new materials and technologies such as flow batteries and graphene-based solutions.
- Affordable seasonal heat/cold storage is shifting the season-to-season availability of harvested thermal energy through large-scale natural or artificial storage options such as aquifers and water storage tanks.

Long term developments

In the long term, bidirectional integrated grids together with affordable storage solutions allow truly sustainable energy systems. Grids are interoperable, creating mixed thermal, electrical, water and gas networks within a single energy-management system.

The growing affordability and availability of sustainable energy solutions, based on a mix of decentralised small-scale and large-scale installations, lead to an abundance of renewable energy in the long term.

Energy sharing

Short term developments

- In the short term, energy resources at city and district level are mapped and managed efficiently, allowing supply and demand matching between producers and consumers of electricity and heat, with individual buildings as contributors to efficient city-wide solutions.
- Existing energy grids with an increasing share of decentralised renewable energy generation are stabilised at district levels by peak shaving measures and by providing sufficient storage and generation capacity.
- Sustainable energy generation and consumption are regarded as community assets, through which people share corresponding rights and obligations, collectively increasing the total amount of renewable energy of a district.
- Energy performance is evaluated at district level. New buildings with higher energy standards and renewable energy production compensate for the older building stock with a negative energy balance.

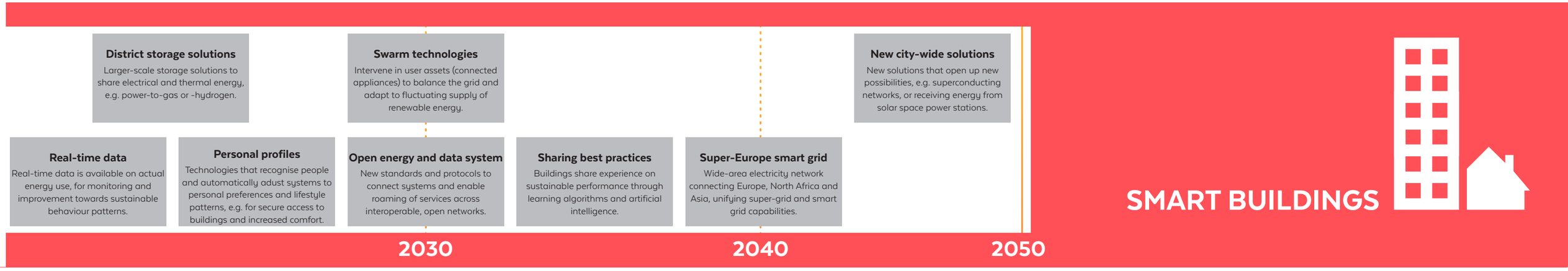
Mid term developments

- Energy grids are self-healing and bidirectional, with a large number of interconnected decentralised production facilities for renewable energy, and mechanisms to ensure grid stability and continuity of service in case of failure.
- District storage systems are used to balance fluctuations in electrical and thermal energy supply and demand using efficient, large-scale storage solutions such as power to-gas and hydrogen.

Long term developments

- In the long term district energy performance is optimised through innovative approaches such as 'swarm' technologies, connecting appliances to self-learning and self-balancing networks and other city-wide solutions such as superconducting networks.

SMART BUILDINGS



ICT & building management systems

Short term developments

- In the short term ICT & Building Management Systems are evolving. This allows increasing generation and use of data for energy optimisation and management in buildings and grids, based on detailed control through smart meters.
- ICT technologies allow the creation and control of smart networks at local level to share electrical and thermal energy among neighbours.
- Right from the design phase, building information management systems allow simulation of building energy performance. This allows their life-cycle energy balances to be optimised and their contribution at district level to be determined.

Mid term developments

- In the mid-term, building and home management systems allow building energy performance and operation to be optimised using public (e.g. weather forecasts) and private (e.g. individual users consumption pattern) data.
- Detailed real-time data is available on energy use and building performance, as well as on user comfort and behaviour, to improve and optimise building operation. This allows the creation of users' personal profiles, with adaptive systems that can be adjusted to match users' personal preferences.

Long term developments

- In the long term, open energy and data systems allow interoperability of networks resulting in performance improvement through mutual learning. This is based on new standards and protocols to allow connection of systems.
- Buildings are active and self-learning, communicating and sharing experience on sustainable performance through learning algorithms and artificial intelligence.
- ICT contributes to the creation of extended smart grids, e.g. a super-Europe smart grid that connects Europe, North Africa and Asia, unifying super-grid and smart grid capabilities.

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VALUES, MOTIVES & BEHAVIOURAL CHANGE

Supportive information
Better and transparent data on the real costs of energy (incl. hidden costs of fossil fuels) and solutions for savings, so people have the right information for behavioural change.

Incentives strategies
Positive incentives for behavioural change to increase sustainability.

Pilot projects & living labs
Experimenting and experiencing the use of model buildings to initiate public discussion, change the aesthetic perception and create acceptance.

Social interventions
Using a range of social intervention mechanisms (e.g. ambassadors, education, neighbourhood competitions) to create a dialogue with citizens and increase awareness.

Evidence-based decisions
The creation of independent knowledge and access to knowledge to support municipalities in evidence-based decision-making.

Transparent information
Better and transparent data for citizens on energy costs in relation to their lifestyle and behaviour.

Making efficiency fun
'Gamification' solutions to counter the 'rebound effect' and to make striving for efficiency is fun, both now and over time.

2016 **2020**

Values, motives & behavioural change

Short term developments

- Behavioural change depends greatly on the availability of reliable data. In the short term the transparency of data is increasing. This makes the real costs of energy visible, including externalised or hidden costs such as those relating to the environmental impact of fossil fuels. This supporting information helps to drive system transformation and behavioural change.
- Incentive strategies encourage people to change their behaviour towards more sustainable lifestyles, motivating through financial and non-financial rewards for individual or collective efforts towards overall societal sustainability.
- Experience and experimentation through pilot projects and living labs promote public discussion and awareness of new building methods and lifestyles. This helps to create acceptance for sustainable buildings, and positively influences the aesthetic perception of sustainable architecture.
- New social intervention mechanisms such as energy ambassadors, specific educational programmes and neighbourhood energy competitions promote dialogue with citizens and increase their awareness of and interest in sustainability.
- Cities can make evidence-based decisions as their access to knowledge increases and changes, with independent entities providing information and supporting municipalities.

Mid term developments

- In the mid-term information is increasingly transparent, ensuring that citizens have clear and transparent access to data on aspects like energy costs, individual lifestyle and behaviour, and the related environmental impact. This information allows individuals to take evidence-based decisions.
- Strategies like 'Gamification' solutions make energy efficiency and related lifestyle changes fun. For example these use personalised apps and competitions between citizens, allowing comparisons of personal performance and changes towards sustainability.
- Lifestyle coaching by experts helps citizens to optimising their personal use of resource relating to their individual lifestyles. This is based on personalised advice based on the available real-time data.

Long term developments

- In the long term personal environmental accountability drives individual behavioural change, avoiding 'rebound' effects. This personal accountability is based on citizens' individual use of goods and services, and takes into account embodied energy, CO_2 emissions and other indicators of environmental and social impact.

SMART BUILDINGS

Lifestyle coaching
Personalised advice based on real-time data to optimise the use of resources in relation to individual lifestyles.

Personal environmental accountability
Consumption-based accountability, including embodied energy and CO_2 emissions from personal use of goods and services.

2030 2040 2050

SMART BUILDINGS

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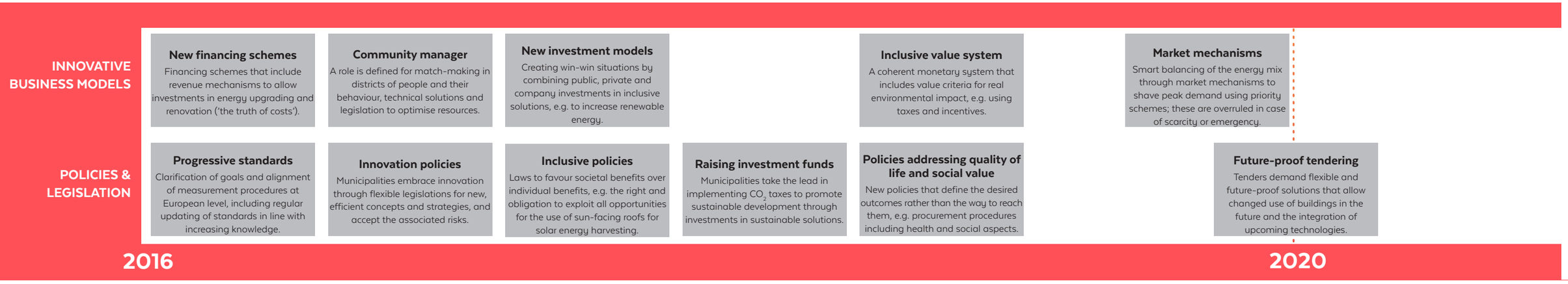


Innovative business models

Short term developments

- In the short term new financing schemes promote investments, for example in energy upgrading and renovation of the existing building stock. This includes new revenue mechanisms based on 'truth of costs', a long-term holistic evaluation of costs and benefits for society.
- The 'community manager' emerges to deal with the complexity of communities. This role is defined for match-making in districts. To optimise the use of resources, the community manager matches the energy needs of people - taking into account their behaviour - with the available technical solutions in the district, and legislation.
- New investment models allow the creation of win-win situations based on combined public, private and company investments. These allow inclusive solutions, for example in the field of renewable energy installations.
- An inclusive value system makes existing monetary systems and mechanisms more coherent. Value criteria for the real environmental impact of products and services are included, for example through taxes and incentives.
- Market mechanisms contribute to balancing the energy system, allowing peak shaving and increasing overall energy efficiency.

Mid term developments

- In the mid-term, new mechanisms such as personal energy budgets allow personalised energy consumption. This could be based on energy credits (similar to mobile phone credits), enabling higher consumption at extra cost as well as discounts for sustainable behaviour.

Long term developments

- In the long term, new business models are based on flexible pricing schemes. This encourages people to contribute to overall grid stability and energy efficiency through flexibility in their use of energy in response to dynamic pricing.
- Contributing to the circular economy, business models are based on a holistic and systemic approach. This takes into account the total value of products and services, including their societal, environmental and economic value at different scales.

SMART BUILDINGS

Personal energy budget
Credits for energy (similar to mobile phone credits), that enable a higher consumption at extra costs, with discounts for sustainable behaviour.

100% renewable energy import
Cities and territory politics ensure that all imported energy is 100% renewably sourced.

Legal security for innovation
Regulations to safeguard health and safety of people while promoting innovative solutions, e.g. safe re-use of 'grey' water in buildings.

Flexible pricing and new business models
People can contribute to grid stability and optimisation by choosing levels of flexibility with dynamic pricing, enabled by swarm technologies.

Circular economy
A holistic, systemic approach and total value business models (including societal, environmental and economical aspects) at all suitable scales.

2030 2040 2050

SMART BUILDINGS

Policies & legislation

Short term developments

- In the short term, progressive standards are based on clear goals at European level and alignment of national measurement procedures, e.g. for nearly zero-energy buildings. These changes are the result of regular updating of standards based on increasing knowledge.
- Innovation policies of municipalities are based on flexible legislations for new, energy efficient and more sustainable building concepts and strategies. Municipalities accept the associated risks to promote innovation.
- Policies are increasingly inclusive, favouring clear societal benefits over individual benefits. For example this results from citizens' right and obligation to exploit all opportunities to use sun-facing roofs for solar-energy generation. In this was citizens contributing to the energy self-sufficiency of city districts.
- Municipalities use mechanisms like CO2 taxes to raise investment funds and to promote sustainable development by investing in sustainable solutions.
- Municipal policies address quality of life of citizens and social values for society as a whole. Desired outcomes rather than the way to reach them are defined, for example in public procurement procedures, including health and social aspects.

Mid term developments

- In the mid-term, tendering promotes future-proof solutions by including specific demands like flexibility and the ability to change the use of buildings, or easy future upgrading with new technologies.
- City and territory policies ensure 100% renewable energy imports as political and societal goal.

Long term developments

In the long term, the legal security of innovations is assured at different levels. Regulations safeguard the health and safety of people and promote innovative solutions. These contribute to sustainability and resource saving, for example by the safe re-use of grey water in buildings.

R4E ROADMAPS FOR ENERGY®

SMART BUILDINGS ROADMAP NEWCASTLE

Sustainable technology

URBAN BUILDING PLANNING

Integrated mapping of assets of existing buildings
Creating an integrated overview of all buildings, their energy performance and potential.

Energy strategy for cultural heritage buildings
Definition of the level of renovation potential, related to legislations for cultural heritage buildings, and available and upcoming technologies.

Rewealthing strategies
Holistic rejuvenation to improve quality of buildings, their use and outdoor environment to update the value of existing building stock.

Flexible use strategies
Redefine the use of buildings (how much space do people need?) and intensify use by sharing private and public space and assets in buildings (community sharing).

City design strategy
Overall strategy for the city, including definition of priority areas in the city for re-use, re-densification and re-building.

Design for disassembly
Designing buildings for easy disassembly to enable re-use of all components and/or materials in closed-cycle systems.

Increasing refurbishment
Accelerating refurbishment and increasing the applicable standards to minimum passive house standards and beyond.

ENERGY-SAVING BUILDING SOLUTIONS

Refurbishment solutions
Passive measures that contribute to energy saving by upgrading the building envelope, e.g. with green roofs.

Modular building blocks
Central production of standardised prefab building blocks, based on the use of sustainable materials and energy solutions.

Highly-efficient buildings
Reducing energy consumption (e.g. insulation and passive solar) and on-site renewable energy production to achieve near-zero-energy new buildings.

Flexible buildings
Making buildings flexible and adaptable over their life cycle, e.g. by designing a suitable grid structure with flexible partitioning.

Customised refurbishment
Specific solutions for refurbishment of existing building stock and cultural heritage, e.g. glazing, ventilation, insulation, heating.

Revaluing nature
Bringing nature back into buildings to enhance health and well-being of users, e.g. green facades or atriums as 'lungs' of buildings.

Energy-positive buildings
Productive facades and roofs allow buildings to cover the energy needs of their users, including extra demand for electric mobility, e.g. all-electric house.

Wood as sophisticated building material
Revaluing technical wood, e.g. cross-laminated timber elements as solution for multi-storey building structures (up to five floors).

MATERIALS & CIRCULAR SYSTEMS

Closed water cycles in buildings
A closed system for the collection, storage, recycling and re-use of rain and ('grey') waste water.

Low-footprint materials
Organic materials, such as clay and wood, locally produced and re-usable, are used in buildings and building structures.

Green waste cycle
Biomass energy solutions based on available local waste resources (e.g. use of urban green waste for energy production).

Systemic water approach
Realising closed water cycles at district level for recycling, retaining and re-use in buildings, terraces and gardens.

Smart life-cycle assessment
Holistic building life cycles, covering all materials, energy use and lifetime societal value are optimised to the maximum extent.

High-performance and eco-materials
Eco-materials with low life-cycle impact (e.g. wood fibre insulation) and high-performance materials (e.g. lightweight aero-gel-foam).

SUSTAINABLE ENERGY TRANSITION

Integrated electrical and thermal energy solutions
Buildings generate sufficient energy to cover their electrical and thermal demand, e.g. photovoltaic in combination with heat pumps.

Electrical and thermal grid
Electrical and thermal grids as storage solutions for balancing production of renewable energy and consumption profiles of the building.

Advanced solar solutions
Applying advanced solar thermal technology, e.g. photovoltaic thermal collectors for electrical energy and hot water / heating purposes.

Small scale co-generation
Combined heat and power solutions based on renewable fuels, e.g. biogas or biofuel.

Large-scale renewable energy production
Making optimal use of territorial qualities to generate renewable energy, e.g. wind and solar parks.

Energetic use of all surfaces
Building integrated energy generation solutions, e.g. translucent, flexible and organic photovoltaic, or solar thermal collector facades.

Direct current (DC) systems and decentralised storage
Shared sustainable electricity storage solutions for housing and mobility, in combination with energy-efficient in-house DC grids.

ENERGY SHARING

Supply and demand matching
Sharing of energy by bringing together supply and demand on district level, e.g. using waste heat from industry in private buildings.

Optimising existing grid
Stabilise grid at district level, e.g. by peak-shaving measures and providing sufficient reserve capacity.

Sharing rights and obligations
People benefit from the assets of all buildings in their environment to increase the total amount of renewable energy in the community.

District energy performance
New buildings are designed to achieve higher standards to compensate for the negative energy balances of existing buildings.

MILESTONE 2020
As well as energy efficiency and low carbon technology, the city has started using intelligent management systems, testing different demand management options and integrating these with generation and storage capacity. The council's operational buildings have tested different business models, and examples have been deployed across the council-owned housing stock. The city is open to trials of different innovative technologies and business models, incorporating personal, social, economic and environmental values in the business cases for investments.

Bidirectional self-healing grid
Creating a bidirectional energy grid to ensure stability and continuity of service, e.g. in case of a failure.

ICT & BUILDING MANAGEMENT SYSTEMS

Smart meters
Data gathering to identify measurable units of control or energy districts to optimise energy consumption.

Smart networks
Buildings are digitally connected to electrical and thermal energy networks to share (renewable) energy with neighbours.

Building information management systems
Supporting the design phase of (energy-positive) buildings in order to promote and optimise the life-cycle energy balances.

Building and home management systems
Smart systems use public (e.g. weather) and private (e.g. consumption pattern) data to optimise operation.

Sustainable behaviour

VALUES, MOTIVES & BEHAVIOURAL CHANGE

Supportive information
Better and transparent data on the real costs of energy (incl. hidden costs of fossil fuels) and solutions for savings, so people have the right information for behavioural change.

Incentives strategies
Positive incentives for behavioural change to increase sustainability.

Pilot projects & living labs
Experimenting and experiencing the use of model buildings to initiate public discussion, change the aesthetic perception and create acceptance.

Social interventions
Using a range of social intervention mechanisms (e.g. ambassadors, education, neighbourhood competitions) to create a dialogue with citizens and increase awareness.

Evidence-based decisions
The creation of independent knowledge and access to knowledge to support municipalities in evidence-based decision-making.

Transparent information
Better and transparent data for citizens on energy costs in relation to their lifestyle and behaviour.

Making efficiency fun
'Gamification' solutions to counter the 'rebound effect' and to make striving for efficiency is fun, both now and over time.

Sustainable organisation

INNOVATIVE BUSINESS MODELS

New financing schemes
Financing schemes that include revenue mechanisms to allow investments in energy upgrading and renovation ('the truth of costs').

Community manager
A role is defined for match-making in districts of people and their behaviour, technical solutions and legislation to optimise resources.

New investment models
Creating win-win situations by combining public, private and company investments in inclusive solutions, e.g. to increase renewable energy.

Inclusive value system
A coherent monetary system that includes value criteria for real environmental impact, e.g. using taxes and incentives.

Market mechanisms
Smart balancing of the energy mix through market mechanisms to shave peak demand using priority schemes; these are overruled in case of scarcity or emergency.

POLICIES & LEGISLATION

Progressive standards
Clarification of goals and alignment of measurement procedures at European level, including regular updating of standards in line with increasing knowledge.

Innovation policies
Municipalities embrace innovation through flexible legislations for new, efficient concepts and strategies, and accept the associated risks.

Inclusive policies
Laws to favour societal benefits over individual benefits, e.g. the right and obligation to exploit all opportunities for the use of sun-facing roofs for solar energy harvesting.

Raising investment funds
Municipalities take the lead in implementing CO_2 taxes to promote sustainable development through investments in sustainable solutions.

Policies addressing quality of life and social value
New policies that define the desired outcomes rather than the way to reach them, e.g. procurement procedures including health and social aspects.

Future-proof tendering
Tenders demand flexible and future-proof solutions that allow changed use of buildings in the future and the integration of upcoming technologies.

2016 — 2020

LIGHT HOUSE

Meeting progressive standards
Design strategies will adjust to progressive standards, e.g. zero emission, energy positive or CO_2-neutral approaches to new and existing buildings.

Buildings like natural systems
Buildings adapt to provide a harmonious living environment for their occupants by adopting nature-based strategies, beyond biomimicry.

Local production of tailored building components
New technologies (e.g. 3D-printing, Factory 4.0) enable nearby production of tailored components, supporting flexibility and diversity.

Tailored production of entire buildings
New production technologies, (e.g. 3D-printing and organic materials) allow on-site production of buildings.

Self-adapting buildings
Buildings made of 'living' organic materials that adapt to changing user needs, climatic conditions and usage.

(Re-)use of local materials
Local and tailored production of buildings components, using local opportunities and (re-)use of local materials (e.g. wood, clay).

Adaptive building systems and materials
Materials with changing properties, e.g. insulation with variable heat transmission coefficient or glass with variable translucency.

MILESTONE 2030
All economically viable energy-efficiency measures have been delivered to the domestic stock, together with measures to progressively achieve higher standards. Innovative business models enable the use of low-carbon heating solutions, with the aim of transitioning to low-carbon systems (either district or electrification) when the current heating systems are replaced. All buildings are digitally connected and can communicate their energy demand, enabling the creation of flexible usage profiles. The city acts as an aggregator, supporting the move towards the use of 100% clean energy. The use of net zero carbon technologies in new build and significant retrofits is becoming the norm.

Proactively adaptable materials
Self-regulating buildings that proactively adapt to changing conditions (e.g. weather) and usage.

Urban metabolism
Lease options for construction materials — 'materials as a service' — e.g. no ownership because the materials are part of a closed resource cycle.

Affordable storage solutions
New storage solutions that are cheaper to produce, e.g. flow batteries and graphene.

Seasonal storage
Heat/cold storage and extraction in large water volumes, e.g. aquifers, tanks and surface water.

Integrated grid
Bidirectional, interoperable, open grid, integrating thermal, electrical, water and gas networks into one energy-management system.

Abundant renewable energy
Sustainable energy is widely available and affordable as a result of large-scale solutions such as wind & solar parks and alternatives.

District storage solutions
Larger-scale storage solutions to share electrical and thermal energy, e.g. power-to-gas or -hydrogen.

Swarm technologies
Intervene in user assets (connected appliances) to balance the grid and adapt to fluctuating supply of renewable energy.

New city-wide solutions
New solutions that open up new possibilities, e.g. superconducting networks, or receiving energy from solar space power stations.

Real-time data
Real-time data is available on actual energy use, for monitoring and improvement towards sustainable behaviour patterns.

Personal profiles
Technologies that recognise people and automatically adust systems to personal preferences and lifestyle patterns, e.g. for secure access to buildings and increased comfort.

Open energy and data system
New standards and protocols to connect systems and enable roaming of services across interoperable, open networks.

Sharing best practices
Buildings share experience on sustainable performance through learning algorithms and artificial intelligence.

Super-Europe smart grid
Wide-area electricity network connecting Europe, North Africa and Asia, unifying super-grid and smart grid capabilities.

Lifestyle coaching
Personalised advice based on real-time data to optimise the use of resources in relation to individual lifestyles.

Personal environmental accountability
Consumption-based accountability, including embodied energy and CO_2 emissions from personal use of goods and services.

Personal energy budget
Credits for energy (similar to mobile phone credits), that enable a higher consumption at extra costs, with discounts for sustainable behaviour.

Flexible pricing and new business models
People can contribute to grid stability and optimisation by choosing levels of flexibility with dynamic pricing, enabled by swarm technologies.

Circular economy
A holistic, systemic approach and total value business models (including societal, environmental and economical aspects) at all suitable scales.

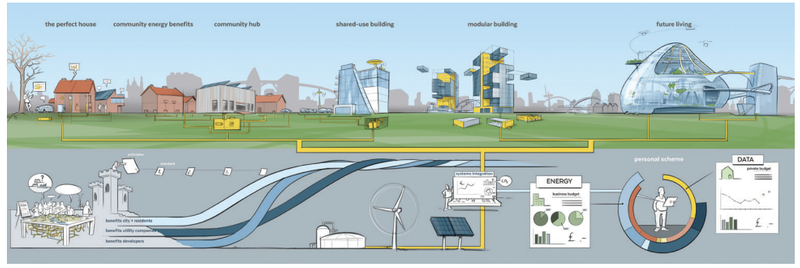
100% renewable energy import
Cities and territory politics ensure that all imported energy is 100% renewably sourced.

Legal security for innovation
Regulations to safeguard health and safety of people while promoting innovative solutions, e.g. safe re-use of 'grey' water in buildings.

2030 2040 2050

Desired future scenario

Newcastle City Council



ENERGY SMART BUILDINGS AND INFRASTRUCTURES ENABLING A HIGH QUALITY OF LIFE AND THRIVING ECONOMY IN NEWCASTLE 2050

In 2050, people in Newcastle enjoy energy-efficient buildings with a high level of comfort. All homes and non-domestic buildings are connected to an effective energy system, to achieve net-zero energy consumption and net-zero emission.

Newcastle has adopted a collective approach to decisions in the infrastructure that enables joint decision-making with stakeholders in the city. Urban planning takes a broad wide-area view to take full advantages of the opportunities extending beyond site or estate boundaries and city limits. Through the open data centre the City Council and its partners are able to implement evidence-based policies and decision-making. Residents are empowered and have the means and the wish to make responsible choices on their own energy usage and investments.

Sustainable buildings

Homes and non-domestic buildings provide high levels of comfort with sustainable energy solutions. They support their users with personalised advice to save energy in line with their lifestyles. Retrofit solutions as well as new innovative buildings ensure that all buildings are sustainable. Buildings are exemplary in their use of innovative and sustainable technologies. High visibility of the solutions supports their adoption as well as a thriving building sector that 'exports' design and consulting services. In this way the standard of the buildings is raised, adding value to existing business models in the local community.

Smart infrastructures

Infrastructure interconnects local grids for different energy sources, such as electricity, temperature control (heating and cooling), water and data, and connect the local grids to regional and national levels. Local grids enable communities to invest in and share sustainable solutions with peers, and support optimal use of renewable energy and the specific features and qualities of separate buildings. All buildings are connected to the grid, receiving and transmitting information to peers or to a wider network with respect for the privacy of the users.

The top layer of the visual represents different type of buildings and sharing options, with an increasing complexity of the solutions. This builds up from a (perfect) house, connected within the neighbourhood, through a community hub around a (public) building, shared use and modular buildings, right up to the future living environment.

At the bottom left the new policy and planning process are shown as a way to manage future-proofing. Elements of the desired future scenario here are the flow of benefits between stakeholders, and city-wide planning (around the table) to align information and decision-making.

At the right of the visual are the underlying infrastructure and personal schemes, which are needed to enable all the other solutions.

Flow of benefits

An integrated planning and development process optimises the flow of benefits for different stakeholders. The value of 'community gain' is considered (not just financial gain) is considered through local integration. A long-term perspective allows business models and decision making to consider state-of-the-art solutions and to avoid the need for renovation. Democratic decision-making enables future retrofitting with participation by residents.

City-wide planning

Policy-making and planning in Newcastle are based on a city-wide plan. This fully integrates all assets and their interactions, so the total impact on the surrounding can be considered. A collaborative approach together with all stakeholders drives alignment of information and leads to better decisions. Through regional cooperation, one set of principles provides developers with progressive standards to achieve sustainable projects.

The perfect house

Houses are designed for people. Connectivity with the energy and data net provides valuable services for comfortable living (e.g. tele-care). People can make responsible choices, even from options they did not think of themselves. The smart house manages itself according to set parameters. Simplicity and accessibility are the norm: people have freedom of choice, with full control oftheir homes and their lives.

Community energy benefits

People living in Newcastle's estates jointly benefit from shared sustainable resources provided through local grid solutions. Residents share energy solutions tailored to their homes (e.g. PV panels on south-facing roofs, or turbines in 'windy gardens', with basement for batteries). The grid provides local interconnectivity promoting community-building and cultural change.

Community hubs

Residents, businesses and public organisations share energy through a two-way interactive local grid. This increases resilience, benefitting from the strengths of the features and investments in other buildings. The benefits of energy investments and production are retained within the community. A smart (virtual) infrastructure allows matching of fluctuations in energy supply and demand of energy.

Shared-use buildings

Smart (wireless) systems enable flexible use of buildings with variable occupancy patterns and users' needs. Office buildings, shopping centres, community buildings and schools can meet varying demands for space by providing the required energy, lighting and heating according to specific user and activity profiles. The building minimises energy consumption by recognising recurring patterns of use.

Modular buildings

Modular buildings offer smart systems, increasing flexibility for reconfiguration of spaces and energy systems (biomass boilers, heat pumps, PV modules). Smart building controls enable internal restructuring. Flexibility de-risks the business case for investors to make the building structures future-proof. Newcastle can exploit its heritage of building large ships and offshore structures to develop core structures that can be clad with modules.

Future living

Citizens' daily living patters have changed significantly. Buildings suit the activities of future citizens, with flexibility between working, living and leisure activities. Future buildings offer a range of facilities and technologies to encourage social interaction.

Personal energy schemes

Individual energy schemes with personal roaming profiles allow the use of (wireless) energy and data where and when they are needed. These provide access to new services such as telecare or energy donations. The scheme enables localised trading, sharing and lending of resources through peer-to-peer networks. The scheme addresses different lifestyles and provides individual budgets and advice for behaviour based on planned and predicted usage.

Energy infrastructure

The energy infrastructure enables gradual replacement of non-sustainable energy sources by renewable energy in buildings as well as regionally (e.g. wind parks and solar farms). Optimisations are done at the appropriate levels, linking local, regional and national grids. Shared data and knowledge from all stakeholders feed into the city-wide plan and support future-proof decision-making. In 2050, Newcastle is a net-zero emissions city.

The R4E project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649397.

Newcastle City Council

The cities plotted the presented current and future projects on a matrix, indicating when the result of the project would be visible in the city (horizontally) and the expected impact on the city, in terms of energy or emission (vertically).

The cities worked together on themes with a potential to become a programme of projects.

PROJECT PORTFOLIO

SMART BUILDINGS

Project portfolio

The aim of Step 4 is to develop a portfolio of projects that the cities can work on – individually or jointly – and that help them to reach their desired future scenarios. The cities created an overview of running projects, and in a joint meeting they selected common ambitions that they all want to pursue. The new projects have to explore many new ways forward. This means that new project proposals are worked out in specific project plans, all relating to the learning opportunities between cities. The financial opportunities are also explored in this step.

Joint workshop

In a joint meeting in Newcastle the cities presented current projects and proposals for new projects based on their city-specific roadmaps. They held in-depth discussions to understand their shared and specific learning objectives and opportunities for joint projects.

First, the cities presented their projects and plotted them on a poster to show when the results will be visible in the city and how they will impact energy and emissions in the city. The picture at the left on the previous page shows the result of this first part of the workshop.

Secondly, a marketplace was held in which city representatives could put forward themes for further development into project portfolios. A theme is a challenge to become a smart city with the ability to grow into a project programme. The themes build on the running and new projects presented by the cities.

In the marketplace, each city took on the role of 'seller' of a theme and proposed it to 'buyers'. The buyers supported the themes, and were able to enrich them by 'negotiation' to include objectives which they considered important. If three cities 'bought' a theme, it was accepted. The marketplace resulted in 14 themes. Together it was decided to merge some of these themes. This left 10 themes for further elaboration in groups.

Thirdly, the cities worked in groups to elaborate the themes by describing their objectives, relevant projects and innovation opportunities. The resulting rich discussion combined the insights of all the experts, and built on the visions and roadmaps.

The groups then presented their proposals in a plenary session, after which all the cities described their learning objectives related to the themes.

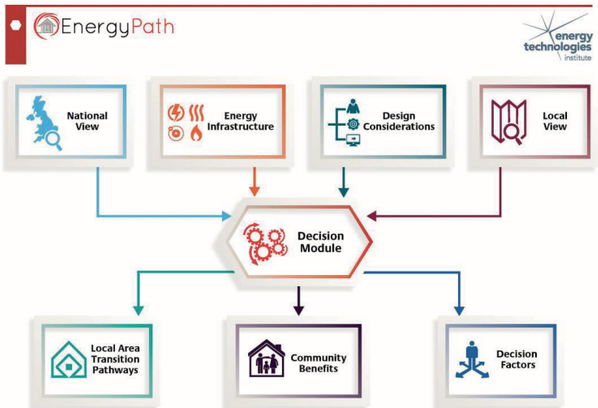
Towards a project portfolio

The themes defined in the joint workshop will be further developed into project portfolios that contain local projects in the cities, but also joint projects, all forming part of the project portfolio. The project portfolios are not included in this report as they will not be made public.

Running Projects Smart Buildings Newcastle

1 ENERGYPATH NETWORK SOFTWARE MODELLING

Newcastle City Council



How to cost optimise the decarbonisation of domestic heating across all residential properties - each building is given a transition pathway, based on multiple factors such as archetype, heat loss profile, demand profile and location.

R4E ROADMAPS FOR ENERGY

SMART BUILDINGS

New Project Ambitions Smart Buildings Newcastle

1 EPC BUSINESS ENERGY MODELLING

Newcastle City Council

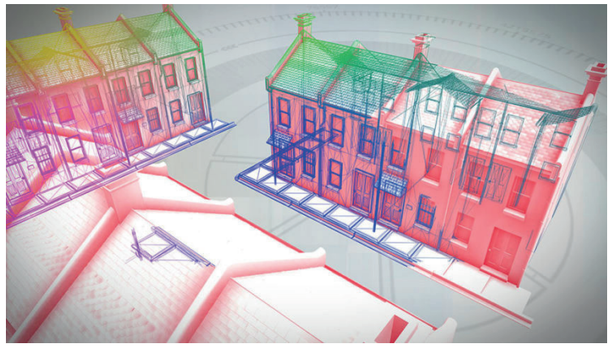
How to minimise loss of rental costs and maximise energy efficiency using business energy modelling and gap analysis of the minimum energy standards for EPCs. The project will include NCC stock, City wide non-domestic and city wide domestic private rented properties.

R4E ROADMAPS FOR ENERGY

SMART BUILDINGS

2 HOME ENERGY SERVICES GATEWAYS

Newcastle City Council



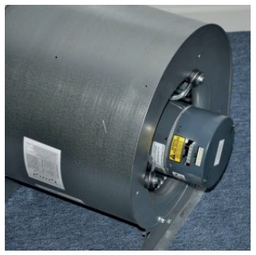
Testing the gas-hybrid ASHP business case in Newcastle. The project will use detailed in-house metering and monitoring to understand individual home performances and occupants needs for heating, allowing residents to control their heat, understand cost implications of changes in behaviour and also allow future energy service providers to sell energy as a service - perhaps comfort contracting, with suitable low carbon heating systems.

R4E ROADMAPS FOR ENERGY

SMART BUILDINGS

3 BARRIERS TO CURRENT BUILDING EFFICIENCY STOCK

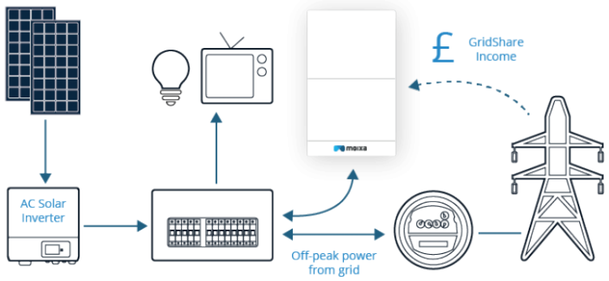
Newcastle City Council



There are a high number of drivers, motors, pumps, gas safety shut off valves and other ancillary equipment across the Council buildings which have been installed over time outside of any centrally controlled carbon management plan. As breakthroughs in technology to reduce energy from such equipment continue the amount of equipment which could benefit from this is unknown and unmeasured.

4 SMART ENERGY BATTERY STORAGE TRIAL

Newcastle City Council



How to make existing solar PV work smarter and reduce tenants and the City Council's electricity costs. Installation of new solar PV with smart battery storage to increase low carbon generation whilst allowing YHN tenants who use economy 7 and 10 heating to benefit from storing energy when at a low price for use when they need it when the price is high. Therefore the project will address: Increased low carbon energy generation.

5 ATTITUDES TO INSTALLING RENEWABLES AND LOW CARBON TECHNOLOGY

Newcastle City Council

Whilst the City Council have installed over 1,000 solar PV systems, principally in housing and a number of biomass and CHP units in non domestic buildings, there is an unknown amount of private landlords and homewoners who have not installed this technology. To undersatnd why this is allows the Council to have better knowledge of how this could be overcome if the City is to realise it's long term vision for energy.

6 OPPORTUNITIES FOR BATTERY STORAGE IN LOCAL AUTHORITY BUILDINGS

Newcastle City Council

The council has installed solar PV on 26 non domestic buildings. The project will focus on an investigation and analysis of opportunities to install battery storage, combined with solar PV on local authority non domestic building stock and adjacent land. This will include the potential for retrofit of battery storage, considering the business case, technical barriers and the opportunity to influence users.

Newcastle City Council

CONTRIBUTIONS

The results in this project are co-created with many stakeholders in the cities. We would like to thank all participants for their valuable contributions.

Participants of the ambition workshops:

- Graeme Armstrong — Newcastle City Council
- Paula Bashforth — Newcastle City Council
- Ged Bell — Cabinet Member for Investment & Development (with Thematic lead for: Climate Change)
- Carlos Calderon — Newcastle University
- Kate Coulthard — Newcastle City Council
- James Davies — North East Local Enterprise Partnership
- Matt Dunlop — Newcastle University
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- Allen Jones — Newcastle City Council
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AMBITION, VISION & ROADMAP
SMART BUILDINGS NEWCASTLE

D6.4 Final city report

This report contains the results of the ambition setting, vision development and roadmapping activities for smart buildings in the city of Newcastle. Workshops were conducted with policy makers, strategy departments, integral project managers, department managers and external stakeholders and strategic partners to define a shared ambition, create a desired future scenario, develop a city specific roadmap and identify initial (local) solutions and research projects to achieve the desired future in the specific context of the city. The participants will continue working on the project portfolio.

This report is the final public deliverable of the Roadmaps for Energy (R4E) project. The R4E partners work together to develop a new type of energy strategy through visions and roadmaps for the 8 partners cities, in co-creation with local stakeholders. The project supports the development of visioning and roadmapping capacities within the municipalities to spur future development and implementation of innovative energy solutions.

R4E ROADMAPS FOR ENERGY®