NEWCASTLE AS A FUTURE

Smart City

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Newcastle as a future ‘smart city’
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Newcastle as a future ‘smart city’

Newcastle is a national leader in sustainability in the UK thanks to crucial efforts made by Newcastle City Council and cutting edge research at Newcastle University in vital areas such as water, energy, transport, computing, digital technology, and many others.

The fact that Science Central is taking place in Newcastle is an example of how the University and council are working together to set a new standard for digitally enabled urban sustainability.

But where are we going, how do we get there and what are the ways you can get involved?

Vision to reality

In our vision for Newcastle as a future smart city we want to show that in many ways this vision is rapidly transitioning from a dream into physical reality. In fact, the programmes of research and technological development that underpin Science Central are already taking place now.

These scenarios or ‘vignettes’ are told from the perspective of the future looking back on the past, which includes our present.

Some scenarios identify the challenges Newcastle is likely to face in its transition to a smart city, but focus on the role of Science Central in bringing together research, innovation, entrepreneurship, learning and engagement required to make it happen.

In these illustrations we attempt to present a vision of what Newcastle could be like as a ‘smart city’ in an exciting and accessible way to encourage collaboration. By ‘smart’ we mean ways digital technology can enable people to make sound decisions about the present and future. Smart also means integrating energy, transport, water and other aspects of the city that underpin everyday urban life.

Science Central is a massive opportunity not only for Newcastle, but the North East and UK as a whole. Many of the things described in these stories are either already taking place in Newcastle, or could be implemented in the near future.

At the end of each scenario are examples of how different stakeholders can get involved from innovative companies to local community groups and policy makers.

The story so far…

Energy

How we generate and distribute energy in the future has the potential to become more local and resilient to faults in the energy network and physical damage. ‘Smart energy network’ describes what this could look like by including the benefits and challenges involved in having a smart grid.

Local energy supply and storage introduces how Newcastle City Council could become its own energy supplier, making Newcastle more attractive to business and effective in finding ways to reduce fuel poverty for residents.

Reducing Floods

Flooding may likely become more of a problem for Newcastle, especially due to increased heavy rain fall as a consequence of climate change. We explore in ‘Green flood management’ how the expansion of sustainable urban drainage infrastructure such as trees and green space in the city helps alleviate flooding, mainly through a community initiative working with local businesses.

In these scenarios we envision that Science Central will not only add value to Newcastle, but improve life in the city making it more sustainable for everyone, and that this future is not far from becoming the present. At the end of each scenario are examples of how different stakeholders can get involved from innovative companies to local community groups and policy makers.

Integrated transport

Transport is the backbone of cities, providing access to resources, jobs and education. ‘Integrated transport’ introduces how Newcastle could benefit from a transport system that integrates multiple transport options. It also explains how smart traffic control and digital sensing networks help to improve the city’s environment and health quality.
Smart energy network

There were many potential causes of power outages including unforeseen failures in the energy grid caused by damage from extreme weather, or even a terrorist attack that could cripple grid infrastructure.

Networking together the computing components that gathered information about the network, made switching decisions and electricity distribution more responsive to physical damages. It also made it more reliable by allowing it to distribute and store energy in ways that were not possible before, and run through a series of energy distribution options much more quickly.

The Cyber Physical Lab at Science Central played a key role in making this possible by bringing together science and engineering disciplines to come up with design techniques that link the digital to the physical. This allowed engineers – for the first time – to explore a wide range of different designs for the computing and electricity sides together.

Once Newcastle’s smart grid had become fully operational it provided ways to manage and reduce the risk of power failures that could potentially leave hundreds of thousands of people without power.

However, digitally enabling the energy network also made the power and information sides of it interdependent. Some risks increased such as the threat of a power cut due to a cyberattack, but by designing the software and computing elements with the physical infrastructure, such as transmission lines and substations, it was possible to build resilience to a wide variety of faults or attacks.

Making better use of assets

Early smart energy network initiatives were about making better use of the assets already in place without having to change the entire energy supply system to meet demand. For it to work it needed to control when to store energy, when to distribute it and how it interacted with the network.

The ability to store energy, add and control energy demand and reconfigure the network was in many ways one of the biggest advantages enabled by a smart grid, which could still provide energy if a large central power station were to go offline. For Newcastle this was tested in Science Central’s Smart Grid Lab.

Scientists at the Smart Grid Lab would simulate the distribution of power under future scenarios including the proliferation of electric vehicles or a power cut due to severe weather. Using data gathered from the Science Central energy network it would run models in real-time that would interact with the hardware on site, including large batteries for energy storage, renewable energy generation and an EV charger.

For the first time, these models integrated the computing network with the power generation, distribution and storage. Developed with the Newcastle Cyber Physical Lab, and the Science Central decision theatre, they enabled all kinds of stakeholders, including community groups and businesses to explore and comment on alternative futures.

Outages

These initial trials were the first step in allowing Newcastle’s energy network to evolve into a ‘smart grid’.

If an outage were to occur the smart grid responds immediately to the fault providing power distributors with detailed information about the Newcastle energy network for operators to make the most informed decisions possible.

If the cause of the outage takes place outside of Newcastle its micro-grid goes into ‘island mode’, disconnecting from the national grid and running on stored energy plus any local power generation, such as from renewables or gas turbines.

If the outage occurs within the smart grid itself it is possible to locate the fault in the network and prevent it from disrupting power distribution to other areas. Using data provided by smart grid sensors, vulnerable parts of the energy network could be identified allowing distributors to focus on making them more secure.

While homes, businesses and municipal services such as hospitals in the city would risk going without grid power for lengths of time on a manual grid, smart grid technologies had reduced if not eliminated the time required to restore power.

This meant that people didn’t have to wait for the power to be restored and were notified of any problems in the energy network via their mobile phone or smart meter. Energy storage, coupled with next generation computing, would keep the lights on and keep you warm if you depended on electric heating.

For public services and businesses that already had power back-up, which were normally not used more than once per year or even less, the city’s smart grid enabled them to be used as a resource for other parts of the city where needed.

This proved to be especially helpful in driving down prices for electricity peak demands, particularly for air conditioning systems which were often driving peaks during summer heat waves. The city’s heating and cooling network also assisted in meeting energy demands that stemmed mainly from indoor climate control.

Other benefits

Another benefit of a smart energy network is that it could notify you about what loads were costing you the most and assist you in finding ways to reduce them. If you were running a washer or dryer during times of peak demand the energy network would inform you that doing the washing an hour or two later could help you save on your energy bill.

It also would summarise in real-time how much energy you were consuming from different sources, and help you plan your own
low carbon strategy. Newcastle’s carbon footprint was 1.67 million tons of CO2 in 2012, with most emissions originating from industry, but domestic use played a large role contributing 34% of CO2 generated by Newcastle, and 30% for the entire country in 2010.

However, for people not really interested in saving energy or reducing their environmental footprint, there were positive incentives given by energy suppliers such as vouchers or other prizes for people who met their carbon reduction goals.

When Science Central was first built in the centre of Newcastle the idea was for demonstrations onsite to extend to the immediate surrounding area, benefitting residents, tenants and commercial partners. It was soon realised that one major business opportunity enhanced by having a smart grid was in energy supply.

**Examples of how to get involved:**

- Work with the labs at the Urban Sciences Building to develop design techniques for building smart grid infrastructure.
- Test prototype smart grid equipment and intelligent consumer products at the Smart Grid Lab.
- Test smartgrid technologies that respond to energy users’ needs.
- Devise solutions for reducing fuel poverty in Newcastle using Decision Theatre.
Local energy supply and storage

Cities consumed most of the world’s energy. While centres of culture, technology and people’s livelihoods they were ironically one of the main drivers in pushing the planet beyond its capability to support human life.

A new approach to supplying energy was needed to address the needs of these concentrated urban areas that required an in-depth understanding of how people use and generate energy to make them more sustainable.

Three themes that remained central to nearly every city in the UK were:

• energy
• transport
• digital technology

The challenge was to integrate them together to create a truly smart way to generate and store energy, using digital sensors that process data locally.

Licensed energy providers

As microgeneration from renewables grew in Newcastle and other UK cities, so did interest in councils becoming licensed energy providers; setting up their own energy supply business and undercutting the market.

There were many advantages of doing this if you were a resident concerned about your energy bill or fuel poverty, a business trying to get off the ground, or a public service that needed more flexibility in how it used energy.

If you were concerned about rising energy prices or where your energy was coming from then localising energy supply made economic and environmental sense. Instead of relying solely upon large energy suppliers where prices would constantly fluctuate, energy from the local supplier could be much more stable and affordable.

Whether you were ecologically savvy or just concerned about paying your heating bill over the winter, a local energy supplier could help make life a little less uncertain.

Acting as an energy supplier fulfilled the council’s objectives in helping people who couldn’t afford spikes in energy costs. It also provided them with the option to change the energy rates charged to businesses to help encourage companies to move to Newcastle, expanding the city’s economy.

However, the process for the council becoming an energy supplier required assistance from forward thinking industries that realised the market potential of local authorities to supply energy to their residents.

In many ways similar schemes for supplying energy locally had been used long ago. For example, the heat network that distributed gas heating to residents at the Byker Estate was an early example of a community energy scheme that continues to this day.

Big Data

The council could use information gathered from the Urban Observatory, process ‘big data’ using computing power from the Cloud Computing Lab, and work with researchers at the Digital Institute. This allowed them to do some detailed modelling of different energy scenarios to see which ones were the most sustainable and cost-effective for Newcastle.

These new models allowed researchers to present new energy schemes at the Decision Theatre. This included looking into how different microgeneration technologies and conservation strategies could impact energy usage, supply and distribution and finding ways to reduce energy demand and improve building energy efficiency.

The most energy inefficient areas of the city could be identified through the Urban Observatory. It was used as the basis for campaigns by local businesses, residents and councillors to conserve energy and cut utility costs by installing insulation.

For the council to supply energy to the city it required cooperation with industries that had statutory responsibilities, providing heat, water and electricity. If they didn’t work with the city to pursue a new form of energy business model then the council’s smart energy master plan for the city would have trouble getting off the ground.

This is where innovative companies, that cut across the boundaries between the public and private sectors, played an important role. Their customers were the partners needed for Newcastle to transform into a smart city that could supply its own energy.

While the city itself has its own smart micro-grid some communities in Newcastle decided they wanted their own local micro-grids too. Through the use of digital governance schemes, neighbourhoods could also have a say in whether they want to invest in community energy storage systems for storing renewable energy generated by local residents.

These community energy schemes worked especially well for areas of the city that have the most residents, who cannot be without power for any length of time without it severely impacting their health.

Newcastle’s smart grid was also essential in bringing online new fleets of electric vehicles that could not only be charged through the city’s energy network via charging stations, but supply energy to it as well.
Examples of how to get involved:

- Discover the benefits of local micro-grids and district heating and power generation by visiting Science Central.
- Design a ‘community energy scheme’ in Decision Theatre looking at saving energy and reducing bills through community organisation and digital technology.
- Test energy storage systems for residential, commercial and local applications using the energy storage test bed.
- Use information provided by the Urban Observatory to find ways to reduce energy costs for communities.
Green flood management

An easy way to mitigate carbon emissions and reduce air pollution in cities is to have more green space. Scientists, engineers, the private sector, local government and city residents were well aware of the benefits of having such green spaces, but the economic case still had to be made.

Green infrastructure, i.e. trees, urban gardens, green space, allotments etc. needed to be implemented in a way that maximised all of its benefits. Ways to plan and pay for it also had to be innovative to get it in the ground.

The answer: using green space to mitigate flooding and adapt to a changing climate.

Annual rainfall increased massively from the 2020s onwards with extreme flooding occurring much more than usual. This was merely a taste of what was in store for not only Newcastle, but for the whole of England with summer rains at least 22% higher than average.

An alternative approach was needed that understood the multiple benefits of green infrastructure. This had the advantage of reducing the occurrence of floods in the city, and in addition provided a cooling service during heat waves and indirect health benefits as green space tended to improve people’s sense of well-being.

As everyone valued green space in different ways this was not always an easy task, but it was essential for creating public forums that otherwise would not have come to fruition. People did agree on actions, especially when their homes or livelihoods were threatened.

Cooperation

Community residents faced high risk of flooding along with local businesses. Together they learned that to mitigate flooding in the city it required cooperation at a scale that was perhaps never done before, or at least not for a very long time.

Using data from the Urban Observatory they located a patchwork of small unused sites that covered a large area. If these were returned to green space they could act as a buffer for reducing future flooding. The Cloud Computing Lab provided ways to store and analyse these data on green space and rainfall in an affordable and flexible way to model and test potential solutions for flood mitigation.

Residents, the council, businesses and researchers could come together in Decision Theatre to share and test ideas about where green infrastructure could be best placed to reduce flooding.

Models developed with the Cyber Physical Lab allowed exploration of alternative designs under different assumptions. These were valuable in getting the right balance between the loss of potentially economically useful space and flood risks.

This approach to flood reduction was inclusive of both community groups and local businesses who were interested in adding more green space, both for flood reduction and to attract customers.

Results

These kinds of initiatives led to more businesses staying in Newcastle not only because it reduced costs associated with damages caused by flooding, but because they were innovative and something they wanted to be a part of. This helped grow the local economy creating new ways for the private sector to engage with local communities.

Eventually the combination of public decision making and green infrastructure solutions for mitigating floods became commonplace throughout Newcastle.

Examples of how to get involved:

• Use data from the Urban Observatory in Decision Theatre to identify ways to reduce surface flooding in the city that affects local businesses.
• Visualise the multiple benefits of green space including biodiversity and flood reduction in Decision Theatre.
• Explore the role of green space for reducing the impacts of climate change using the Cloud Computing Lab.
• Develop an urban planning model using Decision Theatre that includes green space benefits in development appraisal.
• Compare how different sustainable urban drainage technologies operate in emulated and real flood conditions on Science Central.
Northumberland Street
Integrated transport

Since transport is the backbone of jobs, infrastructure, education and access to resources it needed to be more reliable, efficient and accessible. It also needed to be available to all regardless of their age, economic background, or physical ability. Reducing greenhouse gas emissions was essential, particularly from cars, diesel buses and lorries, which were a major source of air pollution in cities worldwide. Newcastle’s digital sensor networks collected, stored and processed traffic and environmental data, which was used to inform travellers of how they could reach their destination more quickly and sustainably, improving life in the city. This transformed how people moved from place to place, and also meant that the impact of transport on a wide range of different sectors in the city could be monitored.

The Energy, Power, Transport Lab and Cyber Physical Lab at Science Central brought together scientists and engineers from different backgrounds to design ways to use information gathered about the transport and energy networks. This included analysing the failures in either power distribution or rail transport to test how they might fail and looking at how they would impact each other. If for example a power dip were to occur how could the energy network be reconfigured to allow the rail system to continue to run, but at reduced capacity until full power is restored?

Mass public transport systems in Newcastle benefited hugely from the city’s smart grid as some of the Tyne & Wear Metro lines had become increasingly dependent on key substations, eventually exceeding their capacity. Smart sensors installed on the lines enabled trains to consume energy as they accelerated away from the station, and send energy back to the grid when slowing down or stopping. Energy storage from the smart grid tested at Science Central helped to balance loads placed on substations that supplied power to the Metro. Integrating information on transport, commercial and residential energy usage allowed distribution of electric power to the rail system in the most efficient way possible.

Rise of the EV

While travel via rail, cycling and bus became more integrated throughout Newcastle, electric vehicles (EVs) emerged as an efficient, low-carbon and cheaper means of transport in the city than fossil fuel powered vehicles. There were questions early on about how widespread deployment of EVs would not only reduce air pollution in the city, but provide a variety of services to the energy network. It wasn’t merely a matter of making electric transport widely available and easily accessible, but integrating infrastructures that would support an electric vehicle transport network, including rail.

Electric cars had become simply one part of a much greater solution to developing a sustainable, economic transport system available to everyone. Receiving data from sensor networks throughout the city helped speed up drivers’ journeys and reduce energy costs. When plugged in they provided services to the electricity grid and became mini power plants giving drivers the opportunity to sell energy back to the grid. While rapid EV charging points have become common in Newcastle the four installed at Science Central helped lead to their widespread use throughout the North East.

Data received via travellers’ smart phones allowed them to identify the most efficient ways for getting where they needed to go. As a result commuters in and outside of the city, especially those travelling at peak times, had a much clearer idea of how long it would take them to travel to work. They also found ways to save time by taking alternative routes, whether they were driving, cycling, walking or taking public transport.

EVs had pre-programmed options including ‘economy low-carbon’ and ‘fastest route possible’ to avoid areas of the road network with heavy traffic. Some of them could also drive themselves allowing for safer as well as more sustainable transport. For hired EVs and car sharing schemes, where the desired journey for the driver was easier to complete by walking, cycling or taking public transport, the EV’s on-board computer would politely inform them of these options in order to conserve energy and save time. Car sharing became more frequent through ‘car clubs’ and similar schemes making it unnecessary to own a car as people often no longer relied upon it as their only mode of transport.

In many ways using EVs as a primary means of transport, similar to travel in combustion powered cars, was not an ideal situation. There were still problems of congestion that needed to be addressed, including a rising population and more drivers on the roads.

Smarter travel and traffic management

Instead of relying on only one form of transport residents became interested in how ‘mixed modes’ of transport could serve their needs, including opportunities to walk or cycle in the city. Mobility schemes were created that did not require the user to own any form of transport so they could cycle during shorter journeys, take public transport for longer ones or a car if their destination couldn’t be reached via rail.

Using information collected from groups of sensors located throughout Newcastle, it was possible to provide travel options focused on commuters’ needs during different times of the day. Early trials of intersections that provide speed advice to drivers helped pave the way for smart traffic management. This allowed motorists to drive through a series of green lights by modifying their speed, helping them to reduce fuel consumption.

Planners looked at what impact adding new cycling lanes in different parts of the city would have on transport overall and how closing down certain roads would affect traffic flow. This allowed them to not only see how implementing new cycle and walking routes could be achieved, but also to understand the knock-on effects they would have on other forms of transport.

Having multiple transport options enabled by digital sensing networks allowed for not only smart, more efficient ways to travel, but helped travellers better understand how they interact with the city.
Examples of how to get involved:

- Test energy storage technology for the grid using the energy storage test bed.
- Develop and demonstrate new use cases for cooperative systems enabling vehicles to communicate with road infrastructure.
- Create innovative drive trains and battery technologies.
- Test second-life applications of electric vehicle batteries.
- Find ways to make integrated transport options more widely available.
Reduce risk of power failures

Exploration of alternative designs

Localising energy supply

Smart ways to generate and store energy

Help to grow the local economy

Adapt to a challenging climate

Driving down prices for electricity peak demands