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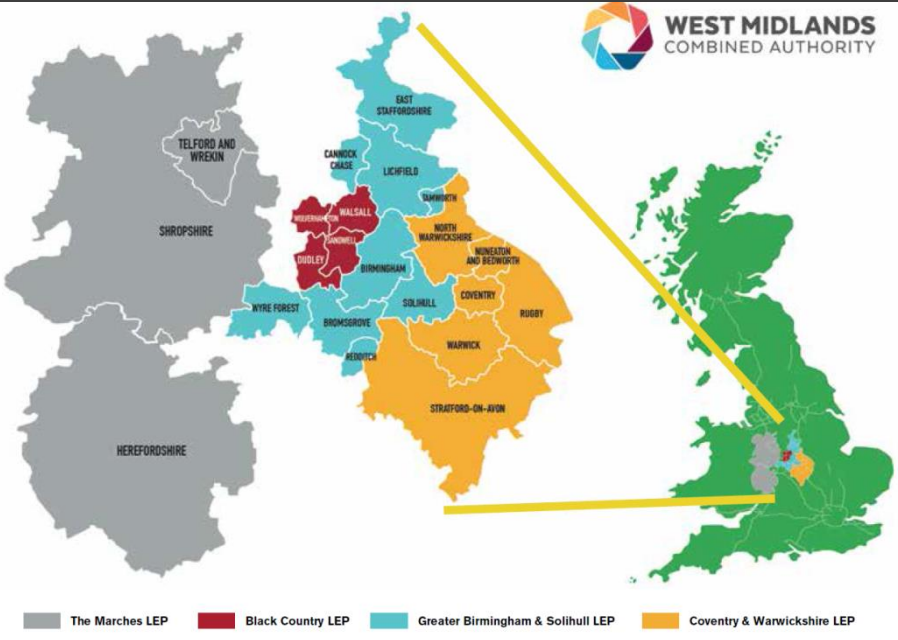
Professor Martin Freer
Director of the Birmingham Energy Institute



OUR AMBITION IS TO ESTABLISH A POSITION OF GLOBAL MARKET LEADERSHIP IN THE

$2.7 TRILLION MARKET

FOR ENERGY TECHNOLOGIES, FOCUSING SPECIFICALLY ON THE SMART AND DISTRIBUTED ENERGY SOLUTIONS THAT WILL SUPPORT THE CONNECTED SMART CITIES OF THE FUTURE.

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CORPORATE SUPPORTERS

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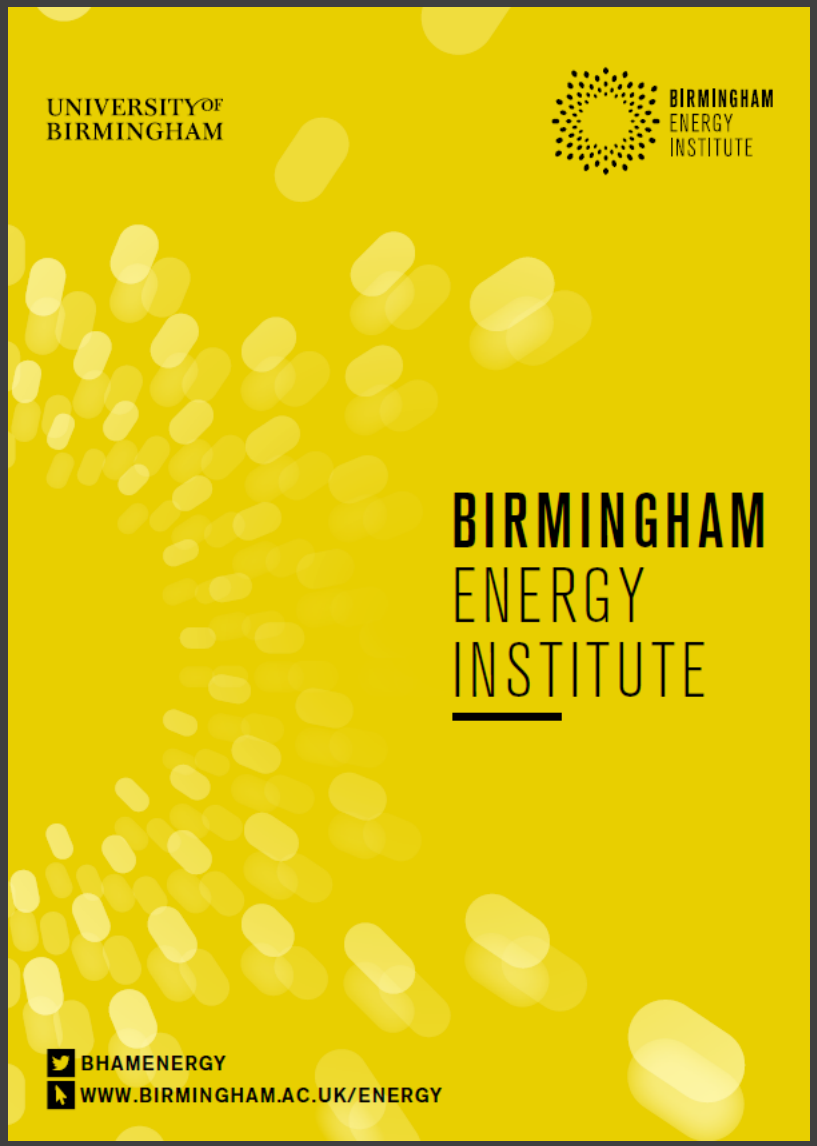
The Birmingham Energy Institute:

BIRMINGHAM ENERGY INSTITUTE

Energy storage
Nuclear energy
Economics
Hydrogen and fuel cells
Transport
Electricity and smart grids
Materials for energy applications
Sustainability
Strategic elements & critical materials
Energy Law and regulation



WE HAVE OVER... **140** ACADEMICS FROM **4** COLLEGES

ENGAGED IN ENERGY AND ENERGY RELATED RESEARCH AND DEVELOPMENT

£75 MILLION

AWARDED FROM EXTERNAL PROJECT FUNDING RELATED TO ENERGY

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UNIVERSITY OF BIRMINGHAM

BIRMINGHAM ENERGY INSTITUTE

Centre for Energy Storage

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BIRMINGHAM ENERGY INSTITUTE

Centre for Hydrogen and Fuel Cell Research

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The Energy Research Accelerator

brings together the Universities of Aston, Birmingham, Leicester, Loughborough, Nottingham and Warwick and the British Geological Survey to form a **£180M** research hub which will deliver on UK expertise and leadership to give the UK competitive advantage in energy research and development.

T-ERA ENERGY RESEARCH ACCELERATOR

To lead the development and integration of a range of thermal (heating and cooling) energy technologies and the global cold economy.

Phase I

- Advanced Thermal Manufacturing Centre
- Seed development of advanced thermal research design capacity and biorefining capability through EBRi/5-BIO

I-ERA ENERGY RESEARCH ACCELERATOR

To deliver integrated energy solutions addressing major energy use markets - buildings and transport - through manufacturing.

Phase I

- National Low Carbon Mobility Centre
- Battery chemistry, scale up and characterisation capability

G-ERA ENERGY RESEARCH ACCELERATOR

To unlock the potential of our indigenous and international energy resources by accelerating innovation in unconventional fossil fuels, carbon capture, geological energy storage and smarter energy use.

Phase I

- Borehole Array stage I
- Community Energy Demonstrator
- Research Acceleration and Demonstration Centre

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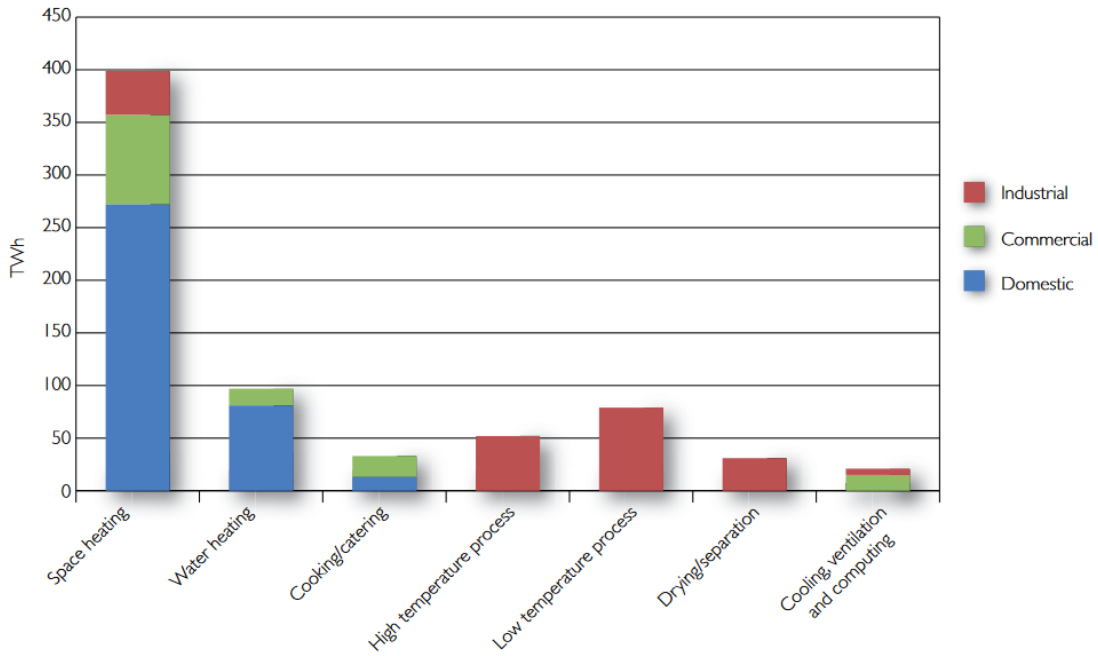
Why Thermal – The Challenge

- "there has been a historic failure to get to grips with one enormous part of the energy jigsaw; the supply of low carbon heat. " **DECC Secretary of State**

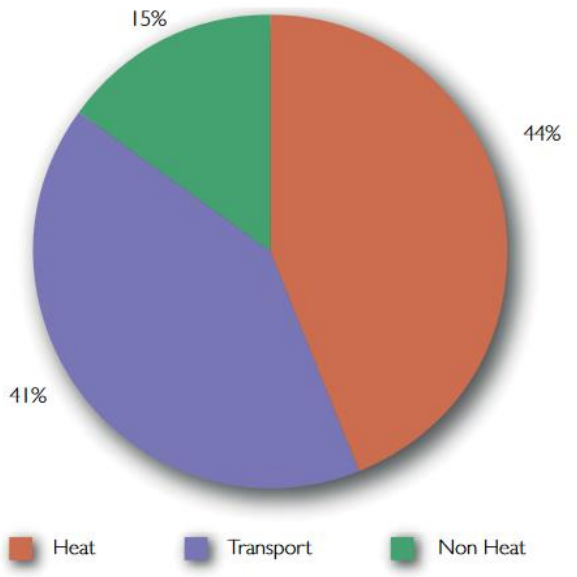
- "we spend £32 billion a year on heating. It accounts for around a third of our greenhouse gas emissions. Without changing the way we produce and consume heat, we will not meet our long-term climate change target. To get there, we are going to have to change the way we generate, distribute and use heat in buildings and industry."

Chart 2: Energy consumption for heating by sub-sector and end-use in TWh (2011)



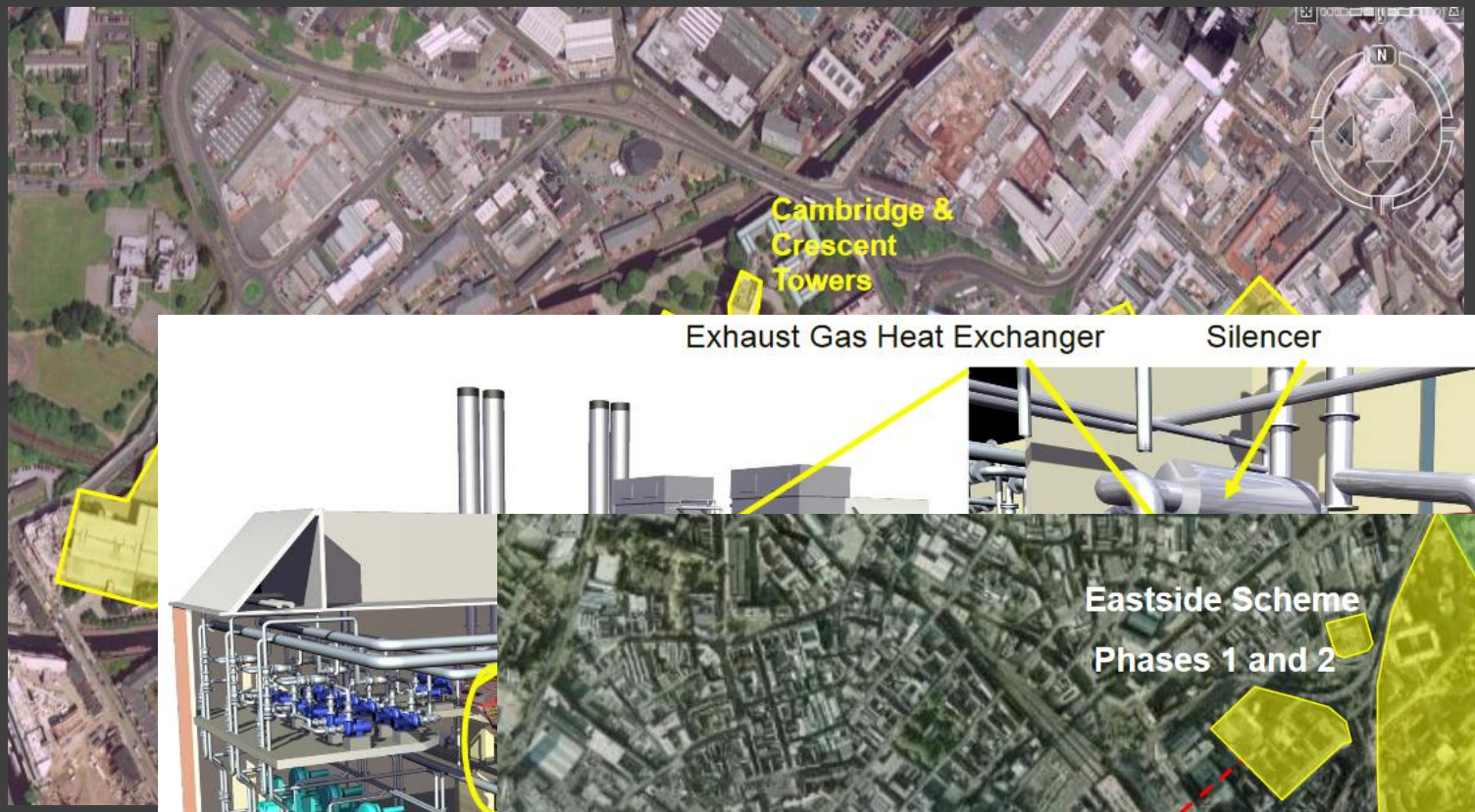
Source: DECC

Chart 1: Energy Usage for Heat, Non Heat and Transport, 2011



Source: DECC

District Heating + Cooling



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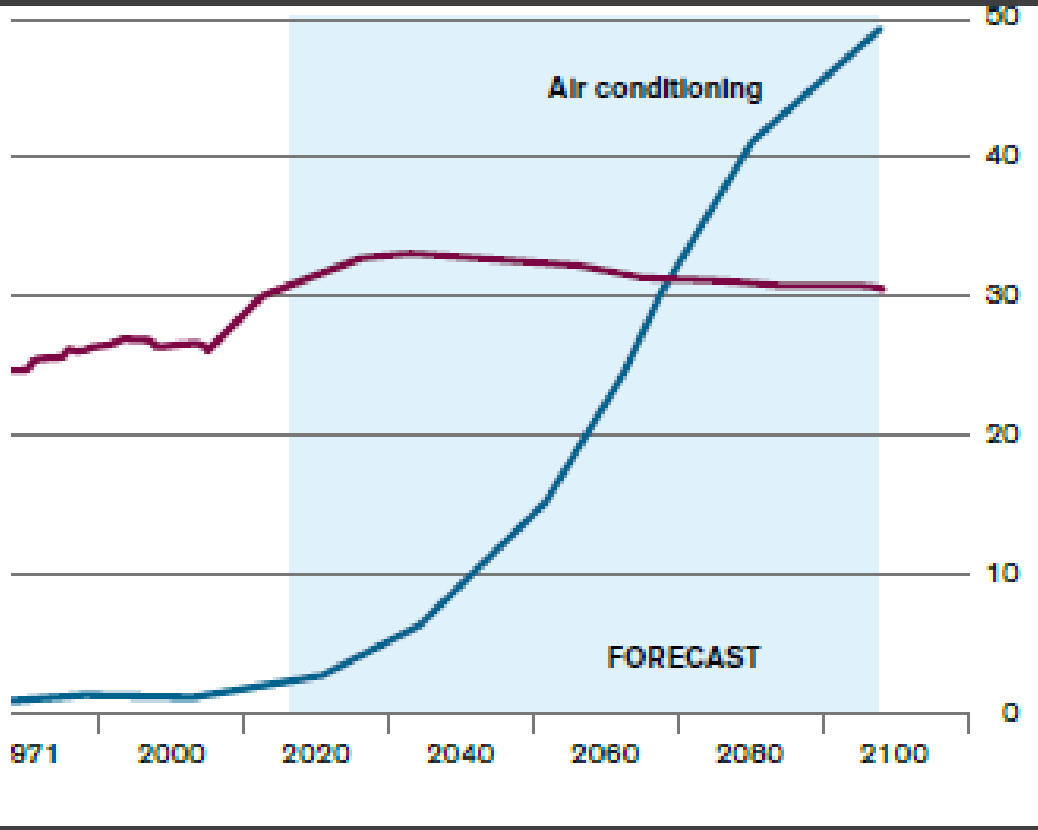
Air conditioning: US uses as much electricity on air con as Africa uses on everything



In 2010 Chinese consumers bought 50 million air conditioning units; more than the entire of the US current domestic air conditioning fleet

DOING COLD SMARTER:
THE FUTURE COLD ECONOMY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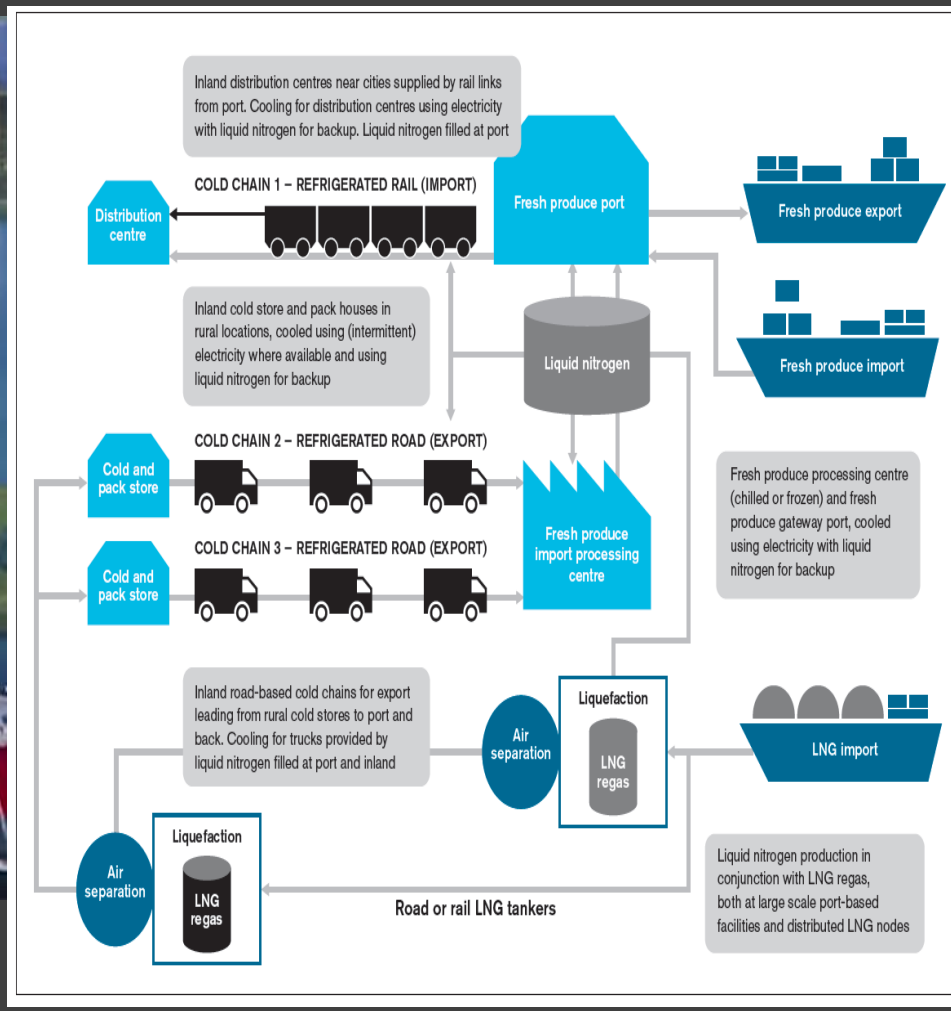

Inland distribution centres near cities supplied by rail links from port. Cooling for distribution centres using electricity with liquid nitrogen for backup. Liquid nitrogen filled at port
COLD CHAIN 1 – REFRIGERATED RAIL (IMPORT)
Distribution centre
Fresh produce port
Fresh produce export
Fresh produce import
Inland cold store and pack houses in rural locations, cooled using (intermittent) electricity where available and using liquid nitrogen for backup
Liquid nitrogen
COLD CHAIN 2 – REFRIGERATED ROAD (EXPORT)
Cold and pack store
COLD CHAIN 3 – REFRIGERATED ROAD (EXPORT)
Cold and pack store
Fresh produce import processing centre
Fresh produce processing centre (chilled or frozen) and fresh produce gateway port, cooled using electricity with liquid nitrogen for backup
Inland road-based cold chains for export leading from rural cold stores to port and back. Cooling for trucks provided by liquid nitrogen filled at port and inland
Air separation
Liquefaction
LNG regas
LNG import
Air separation
Liquefaction
LNG regas
Road or rail LNG tankers
Liquid nitrogen production in conjunction with LNG regas, both at large scale port-based facilities and distributed LNG nodes

Fundamental R&D

Demonstration and validation

Manufacturing and productionisation

Universities

CATAPULT Energy Systems

CATAPULT High Value Manufacturing

Fraunhofer UMSICHT

PHASE 1: T-ERA

Thermal Energy R&D

Thermal Insulation Challenges

- Development of novel thin layer thermal barriers
- Moisture management
- Smart thermal insulation
- Embedded thermal intelligence
- Integration of storage and insulation
- Re-engineering of existing thermal insulation materials
- Development of manufacturing and maintenance approaches for thermal energy deployment

Thermal Technologies

- Heat pumps (air, ground, water (incl. waste)
- Solar to thermal
- Fuel-cells
- Gas boilers
- Bio-digestion
- PV to thermo-chemical to heat
- District heating
- Combined Heat and power
- Cryogenic systems

Heat and Cold

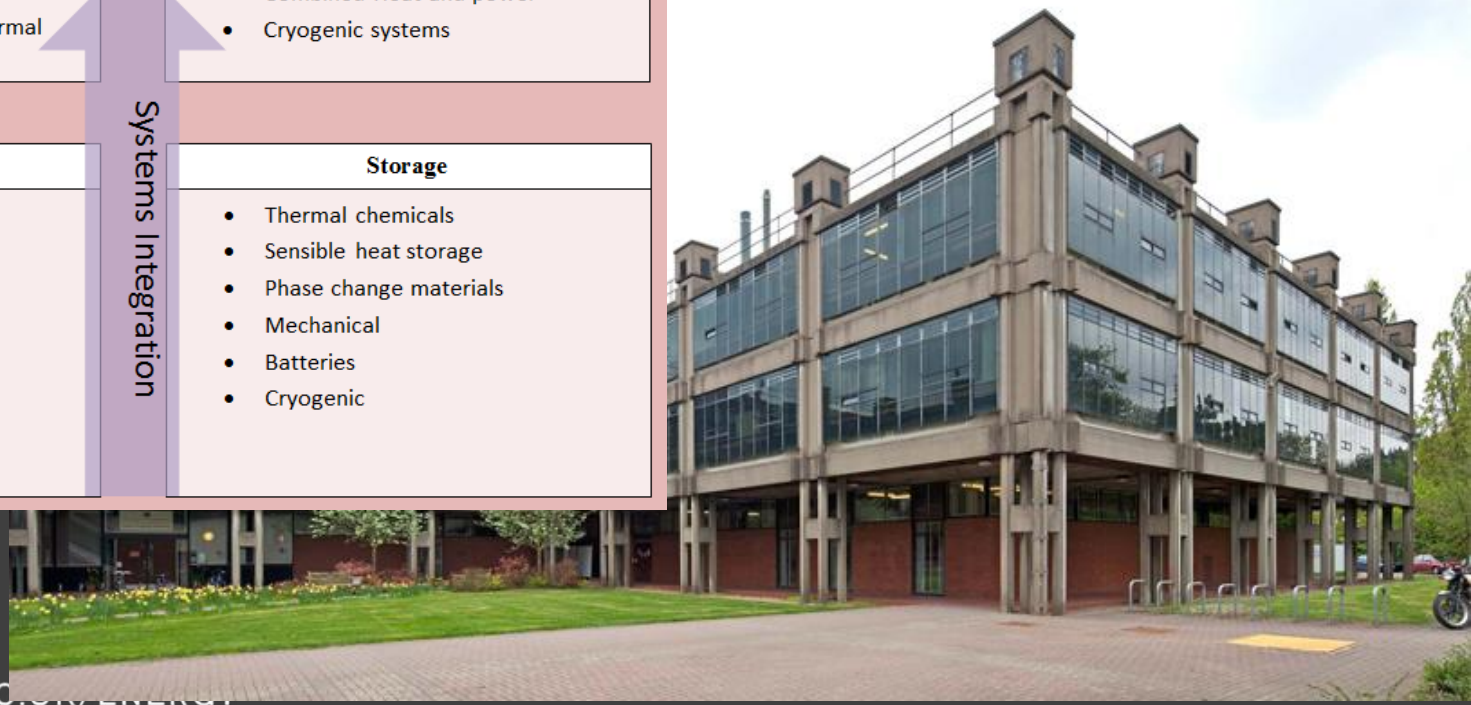
Systems Integration

Energy vectors

- Gas
- Electricity
- Hydrogen
- Thermal fluids/gases
- Liquid gas
- Compressed air
- Biodiesel
- Waste

Storage

- Thermal chemicals
- Sensible heat storage
- Phase change materials
- Mechanical
- Batteries
- Cryogenic



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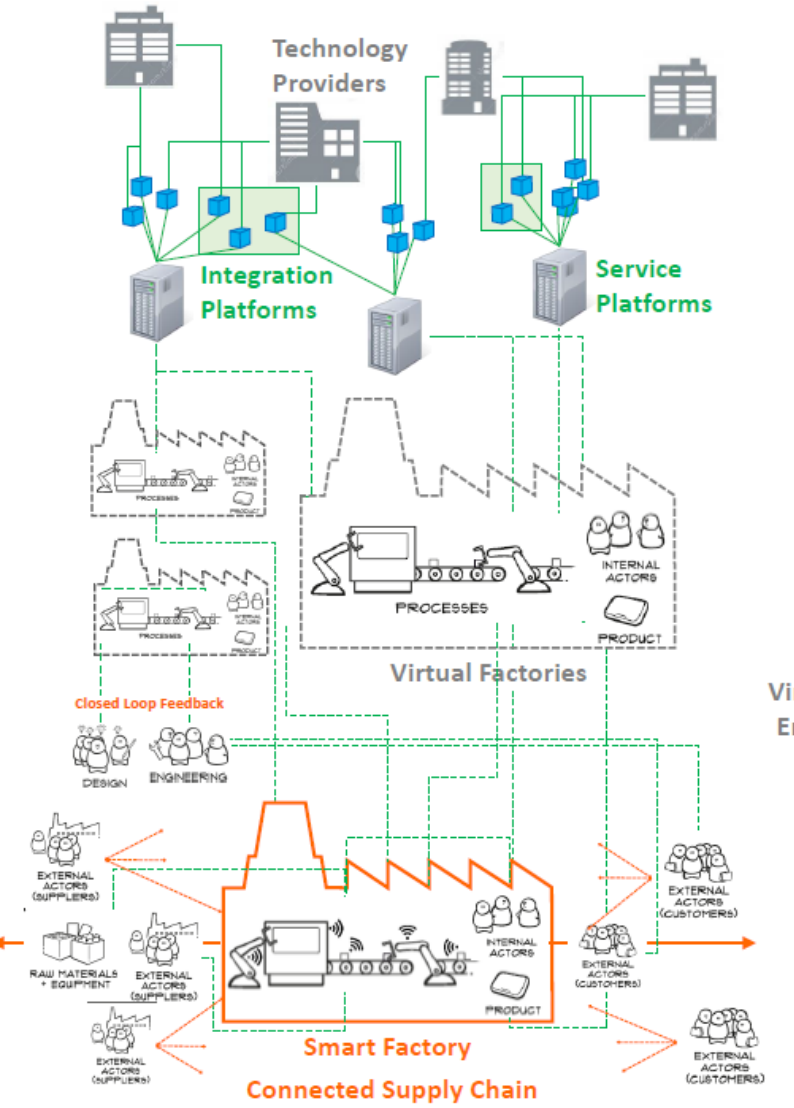
FUTURE SUPPLY NETWORKS



TECHNOLOGY AREAS

Enablers

Information Solutions, Advanced Analytics and Intelligence as a Service

Service Platforms for Service Provision and Connectivity

Horizontal Communications as Enablers of Networks and Connectivity

Virtual Factories as Test Beds and Enablers of Informatics Services

Autonomous Robotics and Control

Cyber-Physical Production Systems

ITEMA
International Thermal Energy Manufacturing Accelerator

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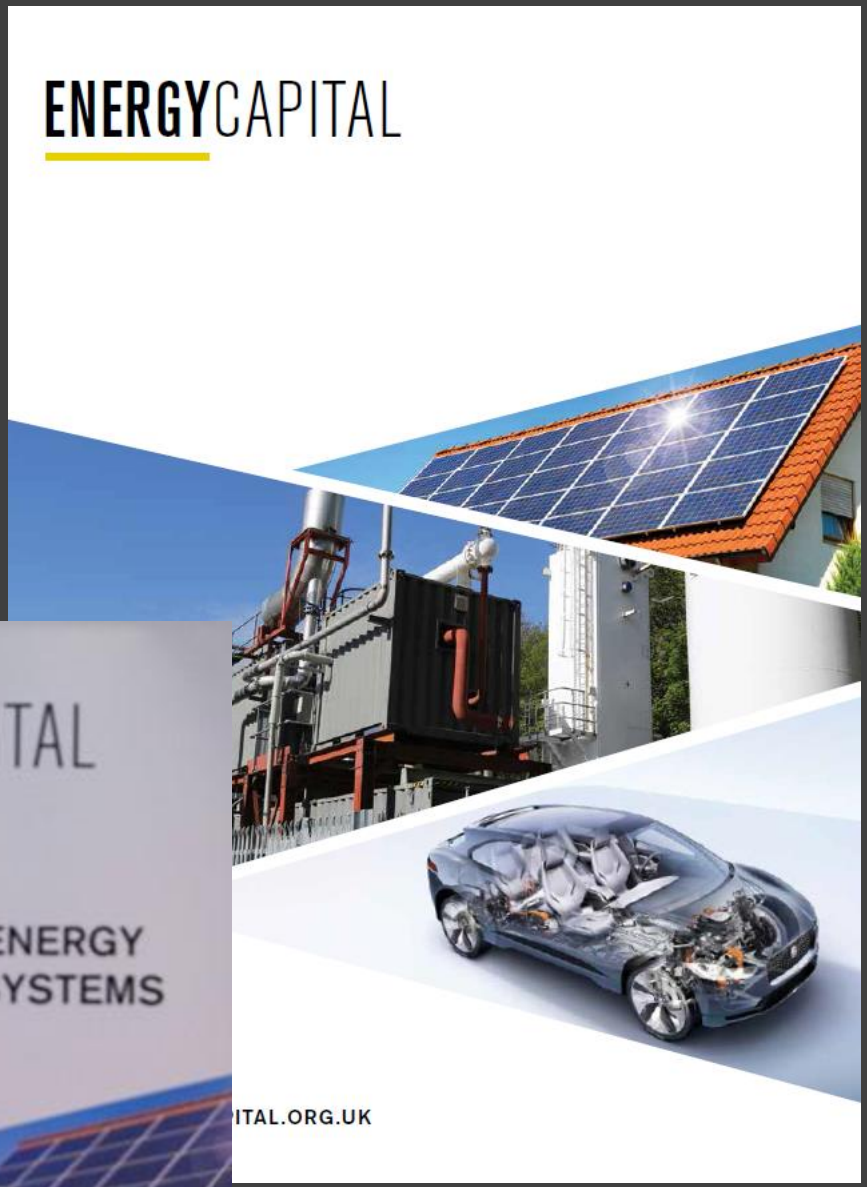
Energy Capital

Transform West Midlands into a UK centre of excellence for energy innovation

Energy Innovation zones
New business models
New regulatory models

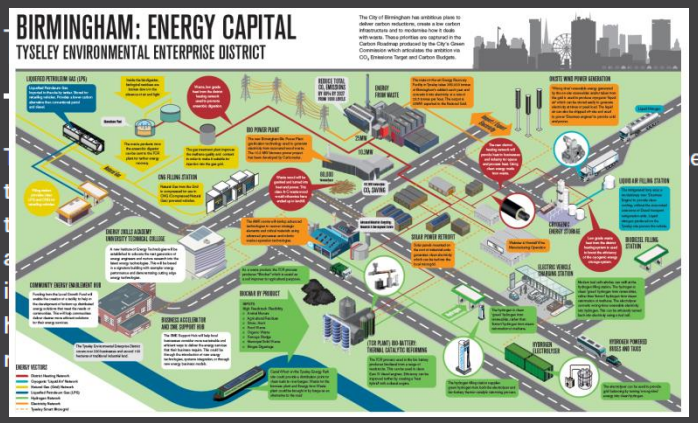
A Birmingham Energy Company



Energy Innovation Zones

BRIGHT PLACE FOR SYSTEMS INNOVATION

BPSI at Aston University will provide a specially designed technology demonstration and research base for new and integrated low carbon systems technologies and services. It will combine energy, transport and smart city perspectives and deliver aspects of the 'mobility as a service' agenda. The Bright Place will be at the heart of Birmingham's Knowledge Quarter, cementing our world leading position in the energy sector by integrating and expanding the critical mass in university R&D, innovation, education and skills.



HOUSING DEVELOPMENT OF THE FUTURE

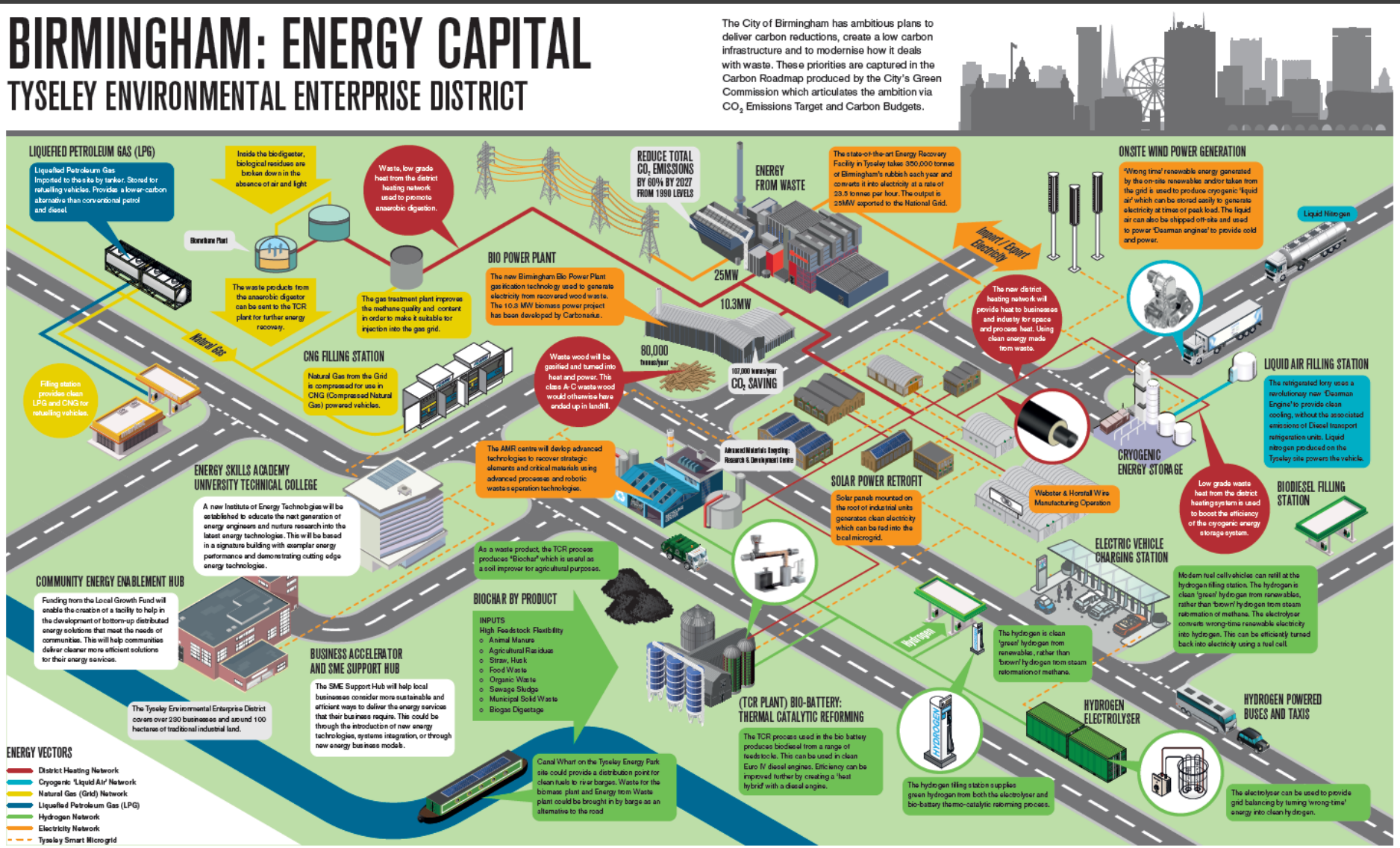
The redevelopment of the Wolverhampton Canalside Quarter presents an opportunity for the construction of new best-in-class energy efficient houses. With building-integrated solar, battery storage, EV charging and smart technology for energy monitoring, control and use, this housing estate will provide a template for future energy efficient dwellings.

POWE

Our grow
supplied
business
manufact
and infras

management and intelligent vehicle to grid technology, the car park facility can be used to help balance the grid.

Large Scale Demonstration



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