Materials UK
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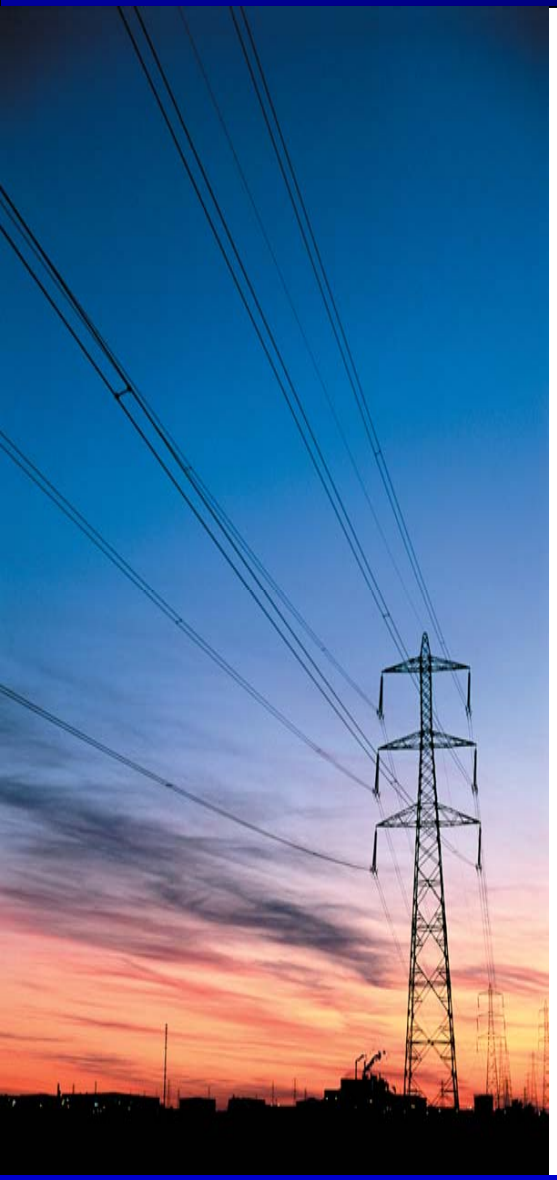
Energy Materials

Energy Transmission, Distribution & Storage



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Andrew Hyde	AREVA T&D
George Morris	Qinetiq
Jennifer Copper	National Grid
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4th December 2007

Materials UK – Energy Materials

Strategic Research Agenda (SRA) Launch

Tate Britain, Millbank, London

Scope

Materials R&D issues related to the following:-

- The Transmission and Distribution of energy
  - Electricity
  - Gas
  - Oil, including networking issues.
- Storage issues associated with
  - Electricity
  - Gas
  - Oil
  - CO_2
  - Hydrogen *(covered elsewhere)*
- Issues associated with transportation of fuels
- Specific issues associated with renewable & distributed power

Energy Transmission, Distribution & Storage

Why R&D Strategy on Energy Materials for Transmission, Distribution and Storage ?

Energy Materials

The Power Delivery System at Global level is Stressed

Significant power blackouts becoming common

UK Energy Challenges

- **Requirement**
  - Deliver a kWhr from **anywhere** to **anyone** at **anytime** at low cost and reduced maintenance
- **Constraints**
  - New large-scale generation is likely to be remote from urban load growth
  - Aging legacy system
  - Deregulation changes system planning
- **Need for National Programme**
  - The UK safety, security, and economy dependent on reliable electric power
  - New sources from Renewable & Distributed Energy
  - Core technology is common among all utilities and no one can afford to develop it for the good of all.

Energy Transmission, Distribution & Storage

UK Skills and capabilities

UK Skills/Capabilities

- ✓ UK knowledge base in current materials used in electricity and gas transmission (due to managing ageing asset base).
- ✓ Exportable knowledge, i.e. feed-through into international Standards.
- ✓ Historic knowledge of old assets sold by consultancies.
- ✓ World Leading Skills and Capability on:
  - ✓ Superconducting and cryogenic applications
  - ✓ Energy storage
  - ✓ Manufacturing of Transmission Pipes

Some examples on UK Capabilities on Advanced Materials

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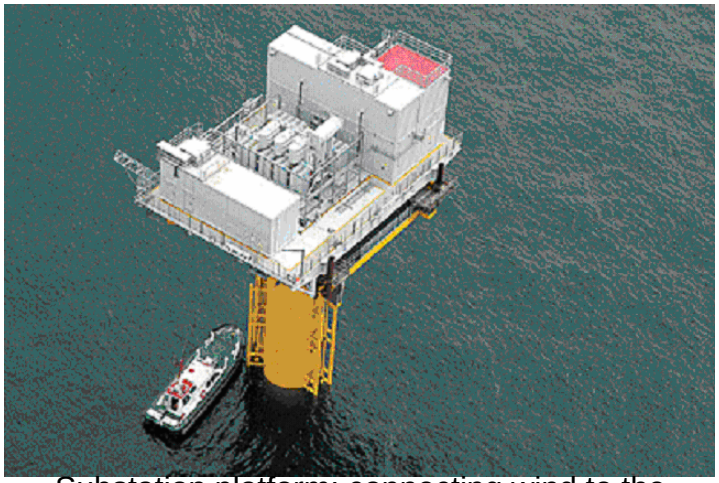


Substation platform: connecting wind to the electricity grid (c) AREVA T&D Courtesy of AREVA

Advanced Superconducting magnet Technology

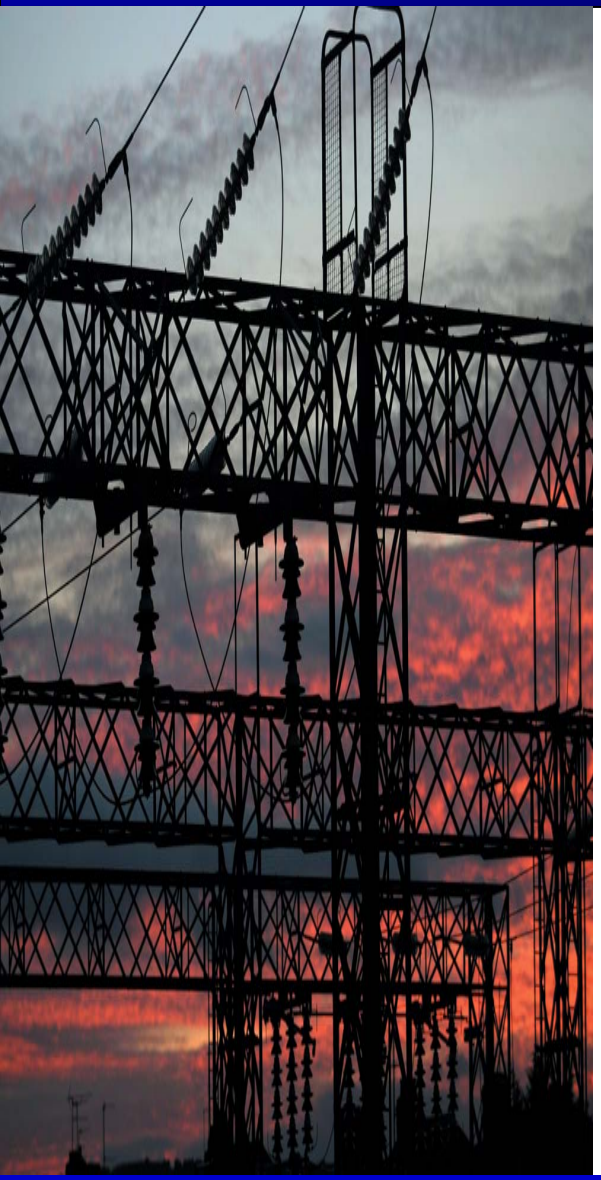
Courtesy of Oxford Instruments

Electric Car using Storage Technology

Courtesy of Strathclyde University

Supercap Field Trial Used for starting 1000shp diesel locomotive with Supercap provides 1500A at 60V (courtesy of MASTCarbon Technology Ltd)

Energy Transmission, Distribution & Storage



R& D Energy Materials Priorities for Transmission, Distribution and Storage

Key Fundamental R&D priorities

- Modelling and the design of transmission and distribution materials/multi-materials for harsh environments
- Development of simulation packages to improve prediction of long-term performance of materials (e.g. + 40 years) to ensure reliability and power quality
- Step change improvement in electrical as well as thermal and mechanical performance of energy materials
- Advanced NDE and condition monitoring techniques

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Short Term Materials Research Priorities **(5 years)**

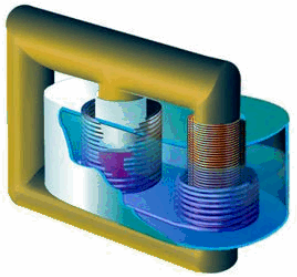
- **Short-term strategic emphasis should focus on the needs of**
  - Electricity network owners,
  - Manufacturers of niche products for the export market (e.g HVDC)
- **Priority national materials R&D themes should include:**
  - Eco-design transmission and distribution products.
  - Development of better/ more compact thermal management solutions for use with high and medium voltage equipment.
  - Establishing the UK electricity industry as a knowledgeable user of electrical equipment that contains nano-materials.
  - Establishing manufacturing technology for advanced polymer composite components for construction of high and ultra high voltage equipment.
  - Producing affordable, low-loss transformer steels and Coatings

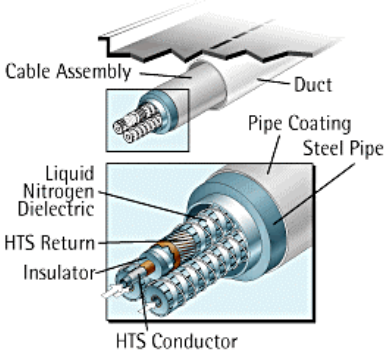
Medium & Long Term Materials Research Priorities **[5-20 years]**

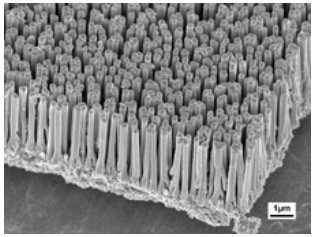
- **Medium & Long Term Emphasis should be on:**
  - Enable the UK grid to increase capacity, reliability and efficiency
  - Provide opportunities for new high technology products and companies.
- **Priority themes should include**:
  - Establishing a national centre of excellence in innovative materials technologies for affordable energy storage.
  - Materials research to enable exploitation of wide-band Gap semiconductor materials (e.g. silicon carbide) in the transmission and distribution system.

Medium & Long Term Materials Research Priorities **[5-20 years]**

- **Other Priority themes should include**
- Materials Developments on
  - Packaging technologies,
  - High temperature supporting components (e.g. capacitors),
  - Thermal management.
- Development of High temperature superconducting (HTS) materials application technologies for
  - Cabling,
  - Fault current limiters,
  - Superconducting magnetic electrical storage (SMES).
- Materials and process development for high strength pipelines,
- Full understanding of fracture properties to allow development of modified design codes for pipelines operating in low temperature regions.







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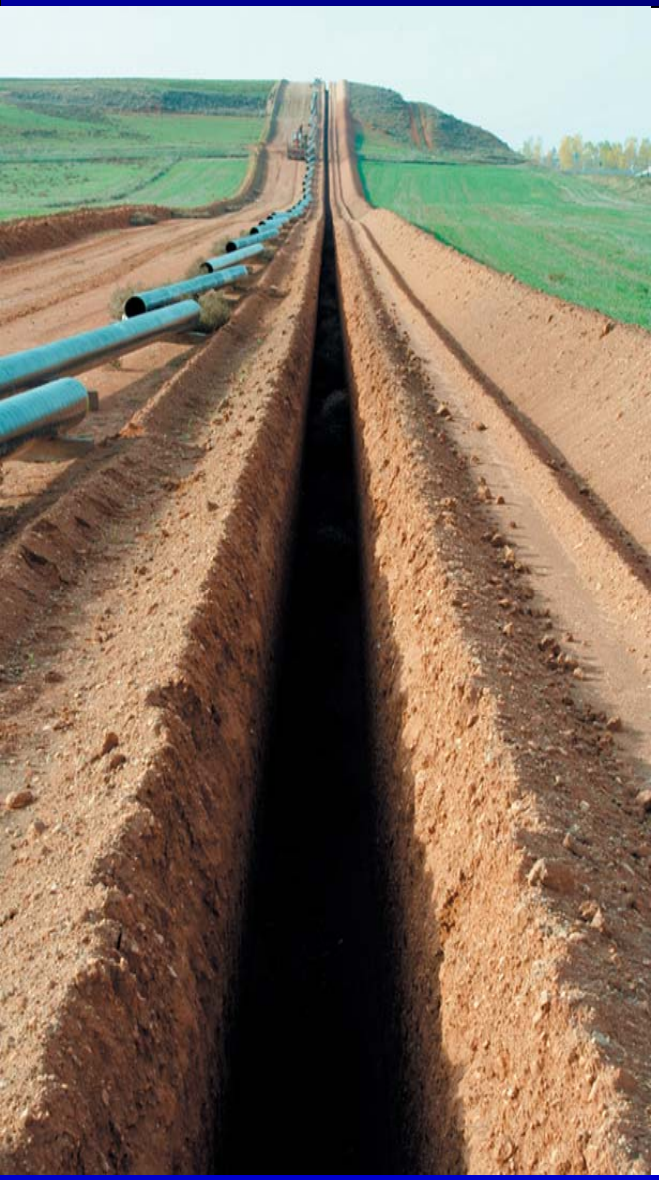

Recommendations

General Recommendations

- Need to capture and collate UK knowledge in energy materials for transmission, distribution and storage together with more recent R&D into a coordinated national TDES archive

- The current asset updating programmes should be coupled with R&D to ensure that the UK has an efficient and sustainable energy system to meet future needs.

- Need to form appropriate collaboration with European and other partners

Recommendations
Electrical Equipment

- Development and demonstration of superconducting fault current limiters
- Research on materials technologies to support application of wide-band gap semiconductors in electrical transmission and distribution for high power switching
- Development of more compact, less intrusive switchgear. The large clearances necessary to withstand high steady-stage voltages and large volumes for arc extinction need to be reduced by improved material and engineering options.
- Development of environmentally friendly dielectric materials.
- R&D on low-loss transformer steels and Coatings to enable smaller quieter and low loss Transformers
- Alternatives to mineral insulation oil are needed to maintain security of supply, particularly from environmentally friendly sources *[such as EDF's current vegetable oil experiments]*

Recommendations
Electrical Networks

- **Smart Networks/Devices to**:
  - Manage Power Demand up to Residential Level
  - Network vast numbers of small-scale Distributed Energy generation and Storage devices
  - Curtail Energy use on Demand
  - Provide detailed energy consumption information for owners

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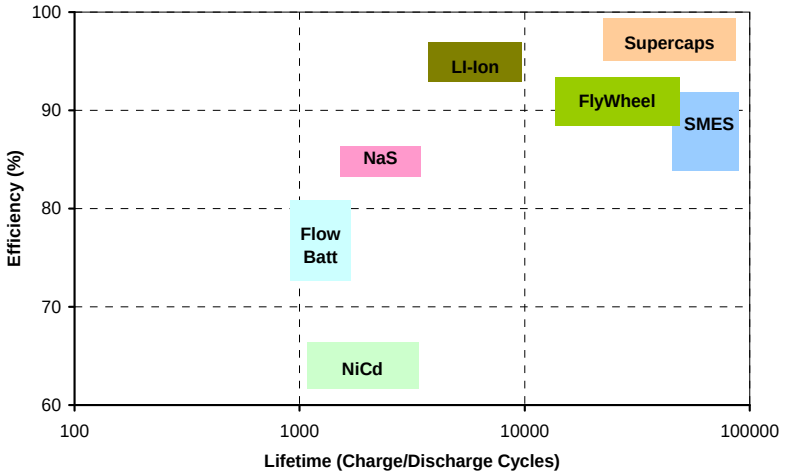
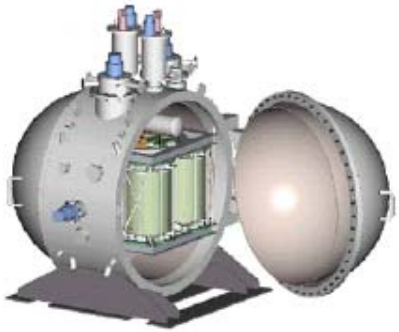
Recommendations
Electrical Energy Storage

- Superior secondary lithium cells using chemistries that do not rely on strategically sensitive cobalt additions.
- Super-capacitors for fluctuating energy storage [e.g. wind turbines] and for hybrid drive regenerative braking systems.
- Flow batteries / fuel cells together with Redox Flow Storage Technologies with emphasis on scale, efficiency and environmentally acceptable operation
- Superconductor-based Magnetic Energy Storage systems (SMES). *Of all electrical storage options SMES provide high storage and release capabilities over a wide range of energy levels.*





Recommendations
Structural Materials

- **High Temperature/High strength conducting wires / cables**
  - would enable overhead cables to carry more power with shorter insulating strings and within a lower silhouette.
- **Advanced materials like High Temperature Superconducting for cables**
  - to enable Future upgrading
- **Materials R&D associated with transmission of Oils and Gas will include development of:**
  - Higher strength and toughness pipeline grades of steel and a fuller understanding of microstructure and properties.
  - Clad / composite pipes
- **More economic corrosion-resistant pipes for corrosive gas mixtures**
- **Lower cost cryogenic materials for Liquid Natural Gas (LNG) transmission and LNG / liquid hydrogen storage**

Conclusions

Materials Opportunities for the UK

- Renewing and upgrading the ageing network presents opportunities to create a T&D system for the future. New and innovative materials technologies will lead to a system that:
  - Is more reliable, flexible and efficient
  - Incorporates renewable and distributed generation
  - Supports development of the internal market

- This presents together with those for the oil and gas industries a range of significant opportunities and challenges to the UK energy materials market and its exploiters

- Materials technology is central to emerging energy storage devices. The UK has a positive research position, which has the potential of yielding a range of lower-cost, longer lifetime devices that could be used in portable and grid-connected applications.

The TDES Report highlight key areas of focus to turn these into reality

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Light Bulb….200 yrs of R&D and Innovation on Materials for Energy

Energy Materials

Proof of Principle				Prototype				Commercial			Cost Effective		
1809	1820	1835	1850	1854	1875	1878	1879	1880	1903	1906	1910	1925	1991
Demo Carbon	Demo Platinum	Demo Carbon	Demo Charcoal	Demo Bamboo	Demo Carbon	13.5 hrs Carbon	40 hrs carbon	1200 hrs Bamboo	1200 hrs tantulum	Costly Tungesten	cheap Tungesten	cheap Tungesten	60000 hrs Tungesten

R&D on Materials for Transmission, Distribution and Storage is the Innovative Route towards Energy Security, Stability and Prosperity