The United Kingdom’s Nuclear Industry Landscape – a UK Nuclear Institute Perspective

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Overview

• The History – how the UK nuclear industry was shaped
• Today – the shape of the UK nuclear industry
• The Future – shaping the UK nuclear industry
• The UK Nuclear Institute
A little bit about me...

- MPhys Physics with Business and Management, University of Manchester
- Joined Atkins in September 2009
- Joined Abbott Risk Consulting Ltd in September 2014
- Chartered Physicist with the Institute of Physics
- Safety case consultancy – based on a wide range of UK sites and projects
- Chaired the Nuclear Institute YGN 2016 and chair of the ENYGF 2017 (volunteer)
- Qualified zumba and HIIT instructor
Some Geography...

- Trawsfynydd
- Bradwell
- Hartlepool
- Springfields
- Capenhurst
- Wylfa
- Hinkley Point
- Heysham
- Torness
- Sellafield
- Wylfa
- Sizewell
- Dungeness
- Sizewell
- Devonport
- Torness
- Hartlepool
The History – how the UK nuclear industry was shaped
The History – How the UK Nuclear Industry was Shaped

• Post-WWII, Britain began production of plutonium and later tritium
• Windscale Piles One and Two became operational in 1950 and 1951
• Windscale Pile One fire – 1957
  • Caused by release of Wigner energy
  • Level 5 on the INES (1-7)
  • Release of radioactivity to the environment
  • Mitigated by “Cockcroft’s Folley” – filter banks installed on the pile chimneys which significantly reduced the amount of radioactive material released
The History – How the UK Nuclear Industry was Shaped

Calder Hall was built near to the Windscale Piles in West Cumbria

- World’s first commercial nuclear power plant opened in 1956 by Queen Elizabeth II
- Design to operation in a 4 year period
- Cost £35m to build
- 200MWe plant
- The first of the Magnox reactors – so called due to the fuel they used which was a “Magnesium Non-Oxidising” alloy
The History – How the UK Nuclear Industry was Shaped

- Magnox reactors
  - 11 built in total across the UK – in Scotland, Wales and England
  - Fuel was natural uranium (not enriched)
  - No Magnox reactor was the same – lots of variations between sites and thus lost potential savings from replicating design and economies of scale. Great for R&D!
  - Last Magnox reactor (Wylfa) shut down in 2016
- Magnox reactor technology exported to Latina, Italy, to Tokai Mura, Japan and to numerous sites in France
The History – How the UK Nuclear Industry was Shaped

- Advanced Gas-Cooled Reactors (AGRs)
  - Government had a choice at the start of the AGR campaign – to follow America’s lead with Light Water Reactor technology or to try a UK-based technology
  - Graphite core and moderator and CO2 cooling
  - Began building in the 1970s
  - 7 in total – all are still generating
  - Now owned by EDF Energy (bought from British Energy in 2009)
The History – How the UK Nuclear Industry was shaped

- Sizewell B – the UK’s only commercial PWR
  - Took many years to obtain permission to build – lengthy public inquiry
  - Came online February 1995 (first discussed as a proposed new reactor site in 1969!)
  - Was supposed to be the start of a huge PWR programme in the UK then privatisation happened
Wide UK Experience with Different Systems

- Sodium-cooled fast reactors
  - DFR
  - PFR

- Gas-cooled reactors
  - Magnox
  - AGR
  - HTR

- Water-cooled reactors
  - SGHWR
  - Sizewell B PWR

- Magnox
- AGR
- SGHWR
- Sizewell B PWR

Year:
- 1950
- 1960
- 1970
- 1980
- 1990
- Present
Today – the shape of the UK nuclear industry
Today – the shape of our industry
Decommissioning

- Lots of unique challenges!
- Novel and complex problems which require innovative solutions
Decommissioning

- Pile Fuel Cladding Silo at Sellafield
Regulation

• The Office for Nuclear Regulation is responsible for regulation of nuclear safety and security across the UK

• ONR was established as a statutory Public Corporation on 1 April 2014 under the Energy Act 2013

• ONR sets out site licence conditions that each licensee must comply with in different ways. The conditions set out the general safety requirements to deal with the risks on a nuclear site.

• Probabilistic, goal setting approach

Office for Nuclear Regulation
**Generation**

- **AGRs:**
  - Advanced Gas Reactor Total ~ 7.6GWe
  - Lifetime extension programmes: Hartlepool, Dungeness B and Hinkley Point B already extended. Expect closures following extensions from 2019 to 2028
  - Challenges – graphite cracking & decommissioning

- **PWR:**
  - ~ 1.2 Gwe
  - lifetime extension expected to 2055
New Build Programme

- GDA process undertaken by the regulators when requested by the UK government

**Steps**

1. Step 1
2. Step 2
3. Step 3
4. Step 4

Granting of a Design Acceptance Confirmation (DAC) and Statement of Design Acceptability (SoDA)
# New Build Programme

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Technology Choice</th>
<th>Site Location</th>
<th>Current status</th>
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</table>
| EDF          | EPR               | Hinkley C, Somerset, England | First nuclear safety concrete pour in March 2017  
1,600 people on site everyday  
Due to come online 2025 |
| Horizon      | UK ABWR           | Wylfa, Anglesey, Wales   | Applied for site licence in April 2017, Design due to complete GDA in December 2017 |
| NuGen        | To Be Confirmed   | Moorside, West Cumbria, England | Investor changes led to Toshiba Corp becoming sole owner of NuGen. |
The Energy Mix

- UK has committed to an 80% reduction in emissions (from 1990 levels) by 2050
- The UK emissions were 42% below 1990 levels in 2016
- In order to meet this target, must reduce domestic emissions by at least 3% per year
- Electrification of the energy mix (i.e. heat and transport) is required
Defence

• Dreadnought is the replacement programme for the Royal Navy’s Trident missile Vanguard Class submarines which form the UK’s nuclear deterrent
• Submarine Dismantling Programme
The Future – shaping the UK nuclear industry
The Future – Shaping Our Industry

Small Modular Reactors

B&W mPower

Westinghouse SMR

Urenco U-Battery

Moltex Energy SSR

NuScale
Energy driver: levelised cost of electricity

Economy of scale: assumes single unit and same design concept (large plant directly scaled down)

Multiple Units: savings in cost for multiple small units at same time (direct - parts and buildings shared; fixed - one time charges; site-related costs)

Nth of a kind learning: cost reduction due to learning (in construction, operation) for a series of units at a single site

Construction schedule: shorter construction time

Timing: gradual capacity increase to fit energy demand growth

Specific design: cost reduction due to specific design concept characteristics, e.g. simplification

Levelised cost of electricity (£/kWe)

Plant capacity (MWe)
The Future – Shaping Our Industry

Economic driver: international export opportunities for SMRs

UK: 7 GWe
Global: 70 GWe

“Small Modular Reactors (SMR) Feasibility Study”, National Nuclear Laboratory, 2014
The Future – Shaping Our Industry

- UK government held a competition to identify the best value SMR design for the UK – phase 1 launched March 2016
- This generated a lot of interest
- Dialogue ongoing between SMR vendors and the UK government
The Future – Shaping Our Industry

• R&D
  • Government R&D funding (fission) was £95m in 2015-2016
  • In the UK, only 1.8% of GDP is spent on nuclear R&D
  • NIRAB was set up to offer independent expert advice to Government – made recommendations (see next slide)
  • NIRO recently set up to provide advice to government and is separate to the NNL
The Future – Shaping Our Industry

NIRAB recommendations for additional research:

<table>
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<tr>
<th>Future Fuels</th>
<th>Making more efficient, safer fuels of the future</th>
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<tbody>
<tr>
<td><strong>21st Century Nuclear Manufacture</strong></td>
<td>Advanced materials and manufacturing - modular build in nuclear factories of the future.</td>
</tr>
<tr>
<td>Reactor design</td>
<td>Delivering the people, processes and tools to make the UK the partner of choice as the world designs SMRs and 4th generation nuclear power plants.</td>
</tr>
<tr>
<td>Recycling Fuel for Future Reactors</td>
<td>Cost effective technologies to deliver a secure and sustainable low carbon fuel supply.</td>
</tr>
<tr>
<td>The UK’s Strategic Toolkit</td>
<td>Informing and underpinning decisions on which emerging nuclear technologies could be brought to market to give the best economic return for the UK</td>
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The Future – Shaping Our Industry

• The UK nuclear industry needs 100,000 people by 2021 – a huge demand for skills
• Many people will be retiring in the next 5 years...
• Not just graduates and apprentices but also transferable skills (e.g. off-shore)
• Nuclear Skills Strategy Group produced a Strategic Action Plan
The Future – Shaping Our Industry

• Brexit means…..?
  • Invoked Article 50 within the letter handed from Theresa May to the EU
  • Britain made a formal notification to leave both the EU and Euratom
  • Euratom is responsible for coordinating and regulating the transport, use and disposal of nuclear materials in Europe, including many of the isotopes used in radiotherapy and some kinds of body scans
  • The Swiss / Canadian model? Need to formalise our own arrangements – and quickly!
The Future – Shaping Our Industry

• Brexit means.....?
  • Potential impact on R&D
    • Nuclear Materials
    • International Nuclear Expertise
  • R&D Programmes
  • Nuclear Facilities
Future Challenges

• Financing and consistent government policy
• Delivery of large scale infrastructure projects: multicultural, complex financing arrangements, huge supply chain involvement
• Historically, nuclear projects are not delivered to time and cost so we must learn from others
The UK Nuclear Institute
The Nuclear Institute

Charity
The Nuclear Institute’s charitable objectives include:
- Support nuclear professionalism
- Encourage education for nuclear energy & technology
- Further public understanding of the uses of nuclear energy

Membership Body
The NI works entirely for its members. Professional development and volunteering across branches and networks

Professional Engineering & Science Institute
The NI is licensed by both the Engineering and Science Councils (for professional registration, Chartership, etc.)
The NI Vision

“The Nuclear Institute will be at the heart of a vibrant and growing nuclear community, driving nuclear professionalism for the benefit of all”
Strategy Themes

- Nuclear Community
- Nuclear Professionalism
- Supporting Nuclear Professionalism
- Members
- Volunteers
- Processes
- Outreach
- Knowledge
- Education
- Collaboration

ni
Advancing Understanding
Giving Members More
Branches and Networks

- Branches – 10 in UK
- YGN – established 1996
- WiN – established 2014

Special Interest Groups

% of women in membership

2008 2016 2017

0 5 10 15 20 25 30
Why does the industry need WiN UK?
• The nuclear industry needs more people
• Women and other groups are under-represented
• A diverse business is a more profitable business
• Diversity facilitates challenge. Challenge is key to safety
Company Membership

- NI partners with the Company to provide NI membership for employees
- Demonstrates nuclear professionalism and CSR
- Supports employee development - access to the Nuclear Delta®
The NI offers professional and learned member grades to suit everyone.
NI Individual Membership Totals

2008: 2500
2009: 2000
2010: 2200
2011: 1700
2012: 1500
2013: 2000
2014: 2200
2015: 2300
2016: 2100
2017 (so far): 2500
Who are our members?

**Age Profile**
- Under 41: 49%
- 41-64: 35%
- Over 65: 16%

**Gender Profile**
- Male: 75%
- Female: 25%

**Membership Type**
- Associate: 63%
- Fellow: 6%
- Affiliate: 10%
- Member: 21%
NUCLEAR INSTITUTE
UPCOMING EVENTS 2017

MODELLING IN NUCLEAR SCIENCE AND ENGINEERING
18 October 2017
Manchester
Join the Nuclear Institute and The International Society of Multiphysics to explore the latest advances in mathematical modelling and simulation behaviour of nuclear materials, reactor safety and environmental effects as well as simulation advancements and deployment of techniques into nuclear science and engineering.
Delegates will hear from leading authorities at the forefront of advancing innovation in Nuclear Materials, Reactor Safety and Environmental Modelling.

WHAT DELEGATES OF PREVIOUS NUCLEAR INSTITUTE EVENTS SAY

"Excellent event overall!"

"A very useful event - did a great job of appealing to a mixed audience"

"Thanks for a really interesting programme of talks!"

"Excellent speakers, networking and discussion"

"This is a new area for me - fascinating and very valuable"

REALISING A FUSION POWER PLANT
8 & 9 November 2017
Oxford
Come to a brand new joint Nuclear Institute / UK Atomic Energy Authority seminar and learn for yourself how close we are to Realising a Fusion Power Plant. Speakers from the fusion research programmes, industry and academia will bring you up to date with the latest progress in the biggest technical challenges including - heating a gas of fuels to 150 million degrees C, exhausting immense heat loads, devising neutron resistant structural materials and making the whole thing remotely maintainable.

NUCLEAR INDUSTRY ANNUAL DINNER
7 December 2017
London
Don't miss your spot at the largest event on the Nuclear calendar this year. With 1,500 attendees in 2016, the 2017 NINIA Annual Dinner promises to be bigger and better than ever, with the greatest minds in Nuclear in the United Kingdom coming together to celebrate achievements in the industry.
For table bookings: events@nuclearinst.com
For sponsorship enquiries: veronica.lekavicius@nauk.org

NUCLEAR SECURITY LEADERSHIP AND PROFESSIONALISM
14 December 2017
London
The 2nd annual Nuclear Security event will build on the highly successful first conference in 2016, which clearly acknowledged the importance of nuclear security organisation integration.
It will explore the latest security threats to businesses operating in the nuclear sector and provide delegates with the latest understanding of what tomorrow's challenges is and how to maintain resilience against the ever-changing threat and risk profiles.

11th INTERNATIONAL CONFERENCE ON THE TRANSPORT, STORAGE AND DISPOSAL OF RADIOACTIVE MATERIALS
15 – 18 May 2018
London
This triennial conference is dedicated to all aspects of transport, storage and disposal of radioactive materials. The conference will provide a unique forum for all involved in this sector of the industry to share information and experience. Call for papers is now open – the closing date for submissions is 29 September 2017.
Visit the dedicated event website: www.ramtransport2018.com

further details on all of these events at
nuclearinst.com

To be announced:
SMR2017 CONFERENCE
HUMAN FACTORS SEMINAR

Contact Amanda at a.macmillan@nuclearinst.com to discuss sponsorship and speaker opportunities.
The Young Generation Network (YGN)
The YGN—Who Are We?

We are a national network of the Nuclear Institute and are a group of like-minded, enthusiastic volunteers.

Our objectives are to provide a platform for:

- Education and Training
- Transfer of skills and experience
- Professional development & networking
- National & International exchange of best practice
- Focus on the next generation
How do we deliver our objectives?

We run a number of events each year and get involved with various initiatives including…..

- YGN Introduction to……defence / new build / power generation / waste management & decommissioning
- STEM events including EYF and Big Bang
- International Links including bursaries to attend international conferences
How do we deliver our objectives?

Networking events

An Audience with.....

Technical site tours

Links with universities & professional institutes

Mentoring

National Speaking Competitions
The benefits of getting involved

• Expand your **professional network** – make new contacts and catch up with friends
• **Learn** about the wider industry
• **Share** your own **knowledge** with others
• Gain valuable **experience** that can help with chartership; both technical and non-technical skills
2017 – An exciting year for the YGN!
What is ENYGF?

**Aims**
- Transfer of knowledge
- Sharing best practice
- International networking

**A Biennial Event**
- 2013 – Stockholm
- 2015 – Paris
- 2017 – Manchester
The Stats

16 Workshops
19 Panelists
54 Posters
250 School pupils inspired

3888 Cups of tea

Unique warehouse venue: 1
Number of attendees: 553
Exhibitors: 42
Technical Presentations: 70
Performers: 17

Number of countries represented: 32
Plenary speakers: 11
Volunteers: 30
Historical city of innovation: 1
Number of UK nuclear sites visited: 15
Thank you to NIRO, NNL, EDF Energy, ARC and Sellafield Ltd for their input to this presentation

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