Hydrogen utilization is imminent in the World.

Wales has a unique agenda to become a leading hub in H2 utilization.

However, storage and distribution of H2 is very complex.

Thus, ammonia offers a solution that,
  • Enables the use of a well-known molecule;
  • Ensures more H2 than H2 itself;
  • Can use a 150 years mature infrastructure

Japan is commercialising solutions for Asia

Nothing similar exists in the West.
Why a centre on NH$_3$ in Wales?

- NH$_3$ complements H$_2$ for long storage, distribution and heavy load.
- Recent advancements on the subject have less than 10 years.
- Industries (marine, power, etc.) are already engaging on NH$_3$ development programs.
- Cardiff has been working on the subject for more than 9 years, surpassing any European university.
- Offshore wind/storage/shipping very relevant to activities within Wales, as well as globally
- Unique Centres of Doctoral Training; MSc in ‘Sustainable Energy’ and ‘Net Zero’.
- First in the West (North America, Europe)
RATIONALE

World’s largest renewable energy project proposed for north-west Australia ditches electricity in favour of ammonia exports

Air Products announce $5 billion renewable hydrogen to ammonia project in Saudi Arabia

GE and IHI Sign Agreement to Develop Ammonia Fuels Roadmap across Asia

First Ammonia Gas Turbine Engine, MHI (H25), 40 MW Power [https://power.mhi.com/news/20210301.html]

Norwegian ammonia shipping network [https://www.ammoniaenergy.org/]

First ammonia-coal co-firing power plant in China for decarbonisation of large power [https://www.ammoniaenergy.org/]
Estimated maturation timelines for energy converters, onboard CCS technologies, and corresponding safety regulations for onboard use

- **Methanol**
  - 2-stroke engine
  - 4-stroke engine
  - Boiler
  - Fuel cell
  - Regulations for onboard use

- **Ammonia**
  - 2-stroke engine
  - 4-stroke engine
  - Boiler
  - Fuel cell
  - Regulations for onboard use

- **Hydrogen**
  - 4-stroke engine
  - Fuel cell
  - Regulations for onboard use

- **CCS**
  - CCS technology
  - Regulations for onboard use

<table>
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<th>Low safety regulatory maturity</th>
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DNV Maritime Forecast to 2050, 2022.
**RATIONALE**

Why the Centre next to the Aberthaw Power Station?

- Japan (leader in ammonia power) has secured a national £345M ammonia program for the use of the chemical in powergen.
- Large demonstrators (~450MW) are currently being commissioned to fully replace coal by ammonia.
- IHI and Jera, industrial leads, are now commercializing the technology in China, Malaysia, India and South East Asia countries.
- Wales can also demonstrate the concept, and commercialize its own technology for power plants all around Europe (ie. Germany, Poland, UK, etc.), positioning Wales as main European Leader in the subject.

**ARTICLE**

**JERA targets 50% ammonia-coal co-firing by 2030**

By Julian Atchison on January 21, 2022

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![Jera demo power station (50% ammonia-coal, aiming for 100% replacement).](image-url)

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**JERA to Conduct International Competitive Bidding for the Procurement of Fuel Ammonia**

JERA Co., Inc. ("JERA"), having decided to conduct an international competitive bid for the procurement of fuel ammonia, has today sent a request for proposals (RFP) describing bidding conditions to more than 30 companies.

Under its "JERA Zero CO₂ Emissions 2050" objective, JERA has been working to reduce CO₂ emissions from its domestic and overseas businesses to zero by 2050, to promote the adoption of greener fuels, and to pursue thermal power that does not emit CO₂ during power generation.

As part of this effort, JERA is working on a project to demonstrate the use of fuel ammonia at the Hitakama Thermal Power Station, aiming to switch 20% of the fuel at Unit 4 to ammonia by the late 2020s. Given the steady progress of this demonstration project, JERA has decided to consider fuel ammonia suppliers in parallel, and to conduct an international competitive bid with the following main conditions:

**Main conditions**

- **Buyer**: JERA
- **Supply period**: Long-term contract from FY 2027 into the 2040s
- **Quantity**: Up to 500,000 tons per year
- **Delivery mode**: FOB
- **Other**: As a rule, CO₂ is either not generated during ammonia production or is captured and stored.
  - JERA has the opportunity to participate in production projects...
Current Outcomes

- 1st National Demonstrator on Green Ammonia Energy (in collaboration with Siemens)
- Director of the Green Ammonia Working Group (UK)
- 2 Royal Society Policy Briefings
- Activity in 8 research grants, with 2 Program Grants
- Publication of 79 (+5 under 2nd review) papers, two books and 3 book chapters
- Editors in Chief of the new Journal on Ammonia Energy
- Lead of the 1st Symposium on Ammonia Energy
- Chair of the Combustion Section of the Ammonia Energy Association
Current Projects

MartiNH3 (NH3 shipping) £1.3M to Cardiff

Ocean RE:Fuel (Offshore-Wind/NH3 storage) £1.0M to Cardiff

Uniquely inc. ‘Ammonia for Power’ £1.5M (17 PhDs)

Responsive Mode SAFE (Ammonia Gas Turbines) £1.2M to Cardiff

HORIZON
FLEXnCONFU Ammonia Power £350k to Cardiff

Industrialised Decarbonisation Research & Innovation Centre £267k to Cardiff

Fuel Switching Competition £45k to Cardiff (potential of a > £3M for phase II)

FLEXIS (Flexible Integrated Fuel Energy Systems) £1.8M to Cardiff

Current Funding Profile
• Current projects are £7.50M
• Expected £3M for BEIS - phase II

Potential Funding Profile
• Current projects’ proposals (under evaluation) £4.3M

Future Projects
• Novel Ammonia storage
• Aerospace
• Combined Heat
• Large Fuel Cells
Immediate Recognised Potential

- Milford Haven LNG Terminal converted into a green energy hub;
- Replacement of LNG by ammonia for
  - Cracking – Hydrogen into the WWU gas grid
  - Direct use for power station (20 MW)
  - Fertilizing activities
- Innovation in Solar/Wind energy to support community use;
- Heat district distribution to surrounding locations.
POTENTIAL PARTNERS
(Institutions and Industries)