Biomass and Fossil Fuel Research Alliance (BF2RA)

2020 Targeted Call for Proposals

Deadline for Proposals - 1700hrs GMT Friday 28th February 2020

Summary

BF2RA (The Biomass and Fossil Fuel Research Alliance) operates a programme to support research into the clean and efficient use of biomass and fossil fuels, to build capacity in this area.

Proposals are invited for specific research relating to the following:

1. Energy Transition
2. Plant Flexibility including materials challenges and approaches for condition based assessments
3. Biomass including Energy Integration/Storage and CC(U)S

Details of these research topics are presented later in this document.

Please note that BF2RA is continuing with single stage project recruitment resulting in a quicker process as described later. Specific conditions will be applied to funded proposals and these can also be found later in this call document.

Background

Globally fossil fuels will remain our most important fuel source for the next few decades. This is primarily for power generation, other conversion processes (such as the metallurgical industry) and general industrial application. In the UK fossil fuels will remain an important fuel source until the mid-21st century although coal use for power generation will essentially disappear by the middle of the 2020s.

There are many facets of fossil fuel and biomass R&D which still need to be undertaken, including managing large scale assets and improving operational flexibility. This will enable the residual use of fossil fuel and especially coal to be optimised.

The energy landscape continues to evolve and will transform the global energy sector from fossil fuel-based towards zero-carbon in the medium term. At its heart is the need to reduce energy-related CO_2 emissions to limit climate change. The energy transition requires the increased deployment of renewable energy sources, energy efficiency measures, energy storage and decentralisation of power generation and electricity and heat grids. The energy transition will be enabled by information technology (including simulation, data analysis and control system development), smart technology, policy frameworks and market instruments.

The research areas identified within this Call aim to align with the foci of the energy related CDTs that launched in 2019 and also with other universities having strong research pedigrees the biomass and fossil fuels areas. Within the new CDTs, BF2RA envisages increased interest in renewable energy integration including energy storage, the use of low carbon biomass and wastes, decarbonisation of gas fired systems, the emergence of bio-energy and the implementation of CCUS. Suitable materials availability is a key element here. Additionally we see the need for increased automation and smart control.

A further benefit of BF2RA research is to provide a new generation of engineers, scientists and technologists. They will be enabled to build capacity both in fossil fuel and biomass related core skills to meet needs in the short to medium term and also those skills to meet longer term energy transition requirements.

BF2RA's Research Portfolio

BF2RA comprises six 'world-class' power generation, equipment supplier, research sector and fuel user organisations and has to date established a portfolio of 33 R&D projects recruited during the period 2010-2019.

The annex to this document contains summary details of the BF2RA current project portfolio together with information on completed projects.

Funding available

BF2RA will provide funding of typically £25-40k per successful application to support PhD/EngD research. Alternatively BF2RA may provide funding for shorter term (typically 6 to 12 month) post doctoral studies at typically £15-25k. It is envisaged that the University will provide the matching funding from CDT, Research Council or other funding sources as is appropriate/necessary.

Research topics against which proposals are invited

Research Area 1: Energy Transition

The energy transition is a pathway towards transformation of the global energy sector from fossil fuel-based to zero-carbon by the second half of the century. At its heart is the need to reduce energy-related CO_2 emissions to limit climate change. The energy transition requires the increased deployment of renewable energy sources, energy efficiency measures, energy storage and decentralisation of power generation and electricity and heat grids. The energy transition will be enabled by information technology (including simulation, data analysis and control system development), smart technology, policy frameworks and market instruments.
Technological challenges will be encountered during the energy transition, including:

- Development of energy storage (thermal and battery) and hydrogen production (steam methane reforming, auto-thermal reforming and electrolysis) technologies and their integration with power plant and industrial plant.
- Waste to energy and power plant integration with combined heat and power (CHP) systems to achieve greater efficiency and reduced emissions.
- CO2 emission reductions through increased deployment of renewable energy sources (RES), carbon capture, utilisation and storage (CCUS) and bio-energy with carbon capture and storage (BECCS) in both the power and industrial sectors. New technologies are required to achieve increased reliability and reduced cost compared with current technologies.
- Simulation, data analysis and control system development for the above themes.

Proposals are invited that address one or more of these technological challenges.

BF2RA strongly encourages the use of digital technology as a means of enabling improvements in this technology area.

Research Area 2: Plant flexibility, including materials challenges and approaches for condition based assessments

Due to introduction of renewable energy sources for power production over recent years there has been a fundamental change in electricity systems and markets. More variable power production increases the flexibility requirements placed on the overall power system, both on the supply and demand sides and it is often claimed that existing conventional power plants, especially large coal-fired power plants, cannot cope with impact of weather-dependent generation of wind and solar power. Flexible operation (rather than base-load generation) is shaping modern power systems and increasing the flexibility of existing power plants is necessary to enable the integration of renewable sources into the system. Coal and biomass-fired plants now operate under widely different conditions from those for which they were designed, consequently, critical components and systems are subjected to thermal cycling conditions not anticipated at the time of their design leading to failure and unplanned operational cost. Many plants are also operating outside of the original design life and fire fuels that are challenging (world-sourced low quality coals and various biomass materials) in terms of plant operation and optimisation. Operational examples include, the failure of pressure parts and process equipment in-service introduces hazards for personnel and plant resulting in significant repair and lost generation costs. Slagging and fouling of heat transfer surfaces adversely affects boiler operations and plant cycle efficiency.

Proposals are invited that address the topic of improved power plant flexibility; recognising challenges for materials and approaches for in-service condition assessment. Topics for research could include;

- General
  - Application of advanced manufacturing studies in the power generation industry
  - Materials issues in relation to supercritical CO_2 power cycles

- Boiler Plant
    - Firing Systems e.g. no. of mills in operation to permit lower load / greater load range; installation of indirect firing systems
    - Pressure Parts e.g. pressure part flexibility / material selection / replacement thinner section of key components(design and manufacturing improvements) for faster load changes
    - Boiler box-up procedures for effective plant preservation during off-load periods
- Turbine Plant and Water / Steam Systems
    - Turbine bypass systems
    - Load following using sliding pressure operations
    - Rapid response for frequency control
    - Energy storage options
- Balance of Power Plant
    - AQCS emissions control plant (SCR / ESP / FGD) / gas path system upgrade
    - Auxiliary plant e.g. use of flexible drives
    - Optimisation of process system and equipment operation, performance and reliability
- Control Systems
    - Optimised boiler / turbine control & monitoring systems
    - Plant control upgrade withself-learning predictive systems
- Materials Behaviour
    - High temperature applications
    - The performance of Creep Enhanced Ferritic Steels (CSEF) such as 91, 92, 93, MarBN, etc.
    - Corrosion
    - Fatigue, response to variable loading and ramp rates
    - Progression to failure
    - Operational reliability
- Condition Assessment
    - Life prediction and models, welds and parent material
    - Non-destructive techniques for assessing material condition
    - Innovative data analytics to improve the utilisation of data currently routinely captured either during an outage overhaul inspection or as part of normal operational monitoring
    - Maximising cycle efficiency with minimal detrimental impact on plant operating life
    - Development of novel fuel quality assessment tools e.g. slagging and fouling prediction indices/tools for aggressive coals, biomass and fuel blends

Within the proposals BF2RA strongly encourages the use of digital technology as a means of enabling improvements in integrity management and operational performance.

Research Area 3: Biomass including energy integration/storage and CC(U)S

Large scale use of biomass for power generation will be a feature of the energy generation landscape for the medium term. Many challenges remain to optimise system performance and to minimise the impact of the biomass production, transportation and utilisation chain. Areas that would benefit from further research are presented below.

- Biomass combustion system technology development for multi-fuel diet diversification for increased dispatch capability – solid, liquid, gas (gasified biomass).
- Integration of energy storage systems with thermal power and industrial plant for waste heat recovery and energy efficiency.
- Technology development to make renewable energy systems dispatchable.
- Biomass pellet grain size management including pulverizing/upgrading solution: in general biomass pulverization and size management.
- Biomass drying and pelleting.
- Impact of biomass shape on loading characteristics for transporting biomass. How to maximise bulk density for transportation.
- Investigation of pneumatic transfer of different biomass materials. Does size and shape affect performance? Is any material or size reduction method worse than any other?
- Mitigating operational risk in low grade biomass boilers through fuel pre-treatment – developing a model to assess component lifetime and operational risk depending on fuel properties; providing validation data (lab based) where there are gaps.
- Slagging, adhesion of slag on coated heat transfer surfaces, impacts of fuel additives to minimise sintering; use of new biomass resistivity model that incorporates the effect of potassium in the ash.
- Tube corrosion mechanisms for biomass woody fuels and its counter-measures including KCl – derived corrosion.
- Integrated ash valorisation – e.g. precious metals in ash and approaches to recovery (economic viability), combined with use of high-carbon biomass ash – i.e. finding a market for both the mineral content and the carbon and producing suitable products.
- Any study on the economic analysis of the cost of generation taking into account holistic aspects of firing biomass derived fuels.

BF2RA strongly encourages the use of digital technology as a means of enabling improvements in this technology area.

The Call Process and Schedule

- Call Issued – by 13/12/2019
- Deadline for submission of Proposals – **1700hrs GMT 28/02/2020**
- BF2RA Panel review Proposals – week beginning Monday 06/04/2020
- Advise outcomes, week beginning Monday 20/04/2020 and initiate student selection and contracting process in preparation for autumn 2020 project starts.

Proposals should be submitted electronically to technical@bf2ra.org by the deadline indicated above.

Proposals must not exceed three pages (minimum font size 10). Further they should include full contact details (email address and telephone number) of the lead proposer/institution. Proposals should reflect accurately the research specification and detail the intended methodology. Proposals should state the funding requested and the full cost of the research together with a summary cost breakdown. Proposals should also confirm the availability of top-up funding should BF2RA offer a grant.

Proposals will be assessed against the following primary criteria (in no particular order of priority):

- Understanding of BF2RA's research areas and their relevance
- Quality of the research proposed
- Relevant skills and expertise
- Demonstration that effective management arrangements and planning are in place
- Industrial relevance, potential for impact and how benefits can be realised e.g. by deployment of models, etc. generated by the research
- Cost and value for money

Special Conditions

BF2RA will manage the monitoring of the selected projects and will provide an Industrial Supervisor for each project. The Industrial Supervisor will be responsible for the monitoring of the project, working closely with the University Project Manager and the BF2RA Technical Officer. This will include the attendance by the Industrial Supervisor at six-monthly project progress meetings, which may also be attended by members of the BF2RA and/or their representatives, and the review of the six-monthly progress reports. Six-monthly progress reports and a final report will be provided by the University Project Manager to BF2RA. A duty of the Industrial Supervisor will be to approve, (or otherwise), these Six-monthly and Final Reports through an agreed procedure prior to making stage payments to the University during the course of the project.

Peter Sage, BF2RA Technical Officer.
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Annex – BF2RA's Project Portfolio

Dynamic Modelling and Simulation of Supercritical Coal-fired Power Plant with CO_2 Capture Ability (Completed). The aim of this project was to develop a dynamic model for the whole supercritical coal-fired power plant by modelling the water/steam cycle and the air/flue gas cycle of a typical supercritical coal-fired power plant. This dynamic model for supercritical coal-fired power plant was linked with the dynamic model for CO_2 post-combustion capture plant (being developed by another PhD project). This enabled determination of a key design and operation issue, namely, whether such a supercritical plant with CO_2 capture ability can satisfy the UK grid requirement.

Intelligent Flame Detection Incorporating Burner Condition Monitoring and On-Line Fuel Tracking (Completed). This project aimed to develop a cutting edge flame monitoring technology that can also indicate the condition of the burner and track the type of coal and/or biomass fuels. This has been achieved by developing a technology for flame stability measurement, burner condition monitoring and on-line fuel tracking through digital imaging and flame signature analysis; evaluating the technology under a range of biomass firing, coal/biomass co-firing, and oxy-fuel fired conditions on a combustion test facility and on a full scale multi-burner furnace; and making recommendations for improvements of existing furnaces through the use of the new technology

Impact of Biomass Torrefaction on combustion behaviour in co-firing (Completed). The principal aims of this project were to investigate a number of the key fundamental issues associated with the development of torrefaction technology for a wide range of biomass materials that will help to promote the more widespread use of torrefied materials especially in the UK. An electrical heated horizontal tube furnace was commissioned for the generation of torrefied fuel. Following drying of the raw biomass, samples of each fuel were then subjected to three different torrefaction temperatures (240, 260 and 280 ^{o}C) and at two different residence times (30 and 60 minutes). The fuels were then characterised using TGA, SEM and C13 NMR techniques. A drop tube furnace (DTF) has been used to generate chars from raw biomass and torrefied fuel samples under a number of conditions with varying parameters such as particle size, residence time and furnace temperature. The combustion reactivity's of the DTF chars has been compared to those generated from TGA experiments. The fundamental results in this study have provided an insight into the combustion properties of torrefied biomass fuels, the kinetic data can be used in CFD modelling to optimise the design of burners for combustion of torrefied fuel.

Avoiding Sintering of Coal-Fired Shallow Fluidised Beds (Completed). The project focused on the investigations of the main causes of bed sintering/defluidization during 'lump' coal combustion in shallow fluidized bed combustors. The project also investigated the effect of co-firing biomass on the bed materials' sintering and fluidization. The 'alkali getter' technique was explored to alleviate/avoid bed sintering/defluidization during co-firing biomass with lump coal in shallow fluidized beds. A range of laboratory based experiments and analysis of materials obtained from an industrial fluidised bed have been carried out. The former has looked at the impact of coal on agglomeration and the latter has focused on investigation of agglomerated material removed from an industrial fluidised bed following shutdown

Milling and Conveyance of Biomass (Completed). The aim of the project WAS twofold, to investigate milling behaviour of a range of biomass materials and to investigate how these milled biomasses impact pipe wear. This was achieved by bench scale milling, analysis of the milled products and design and use of a test rig to rank milled products in a test pipeline. Early work focused on identifying the matrix of different biomass tested on different mills drawn from literature, identifying process variables for specific mill types and the comparison of particle size analysis methods for biomass size fractions. Subsequently a review of the options for characterisation methods for the grinding of biomasses, wear on hammers in mill and hardness of metal vs. Biomass was investigated.

A New Classification System for Biomass and Waste Materials for use in Combustion (Completed). The overall aim of this project was to develop a classification system for non-coal materials, analogous to those which have been widely applied in the utilisation of coals. This involved a comprehensive characterisation of a range of potential biomass fuels in terms of their elemental and chemical analyses along with a study of their structural composition, namely lignin, cellulose, hemicellulose, lipids and other aliphatic polymers such as resins. Further it included an investigation of de-volatilisation and char burn-out behaviour in order to develop the new classification system as a predictive tool for combustion behaviour and its efficacy when applied to blends with coals.

Modelling chemical and micro-structural evolution across dissimilar interfaces in power plant alloys (Completed). This project addressed the Materials Development priority theme of the BF2RA call in that it was directly relevant to the performance, in-service, of fusion welded joints between dissimilar alloys (eg steels and nickel alloys or different steel grades). It was also pertinent to the development of advanced plant components which require protective coatings by weld overlay or thermal spraying for the more aggressive operating environments of biomass combustion.

Development of a Novel Feeding System for Pressurised Combustion/Gasification Processes (Completed). The overall objective of this project was to develop a novel, reliable and efficient system for continuous feeding of solid fuels (e.g. biomass, coal and/or waste) to high-pressure environments. This type of feeding system will enhance the commercial viability of high-pressure gasifiers and combustors operating on solid fuels by increasing the efficiency of the plant as a whole. A new feed system, named Hydraulic Lock Hopper (HLH), has been developed to primarily counter issues with efficiency. The HLH uses water as an incompressible fluid to minimise the energy required for feeding. The HLH has been operated at pressures as high as 25 barg and has successfully demonstrated the feeding of commercially available wood pellets, torrefied spruce pellets and ground anthracite coal grains. The HLH has demonstrated energy savings of approximately 80% at 25 barg for all fuels compared to a conventional single lock hopper.

Low Temperature Ignition of Biomass (Completed): This one year post-doctoral research project commenced in late 2012 and has now been completed. The overall aim of the research was to characterise and measure the ignition properties and temperatures for a range of relevant biomass fuels. The influence of (i) moisture (ii) particle size (iii) oil content (iv) oxygen concentration in the ambient atmosphere, on ignition and reaction was studied. The data has been used to categorize the biomass in terms of its ignition risk in both storage, milling, and transport in entrained flows.

Development of Novel Coatings to Reduce Fireside Corrosion in Biomass-fired Power Plants (Completed): The overall aim of this research is to use a novel, rapid coating development methodology to identify coating compositions that will resist the fireside corrosion environments found on superheater and reheater tubes in combustion plants firing a high proportion of biomass fuels. Specific objectives include: use the "combinatorial alloy development" methodology to generate a wide range of potential coating compositions, to screen these using carefully targeted fireside corrosion exposures to identify the most resistant coating compositions, apply the most promising coating compositions onto heat exchanger tube materials to investigate the thermal stability of the coating/tube combinations and to assess alternative methods of applying the most promising coating compositions onto heat exchanger tubes.
Thermal stability tests of deposits have been carried out to identify a suitable screening deposit composition, which can be used in the fireside corrosion tests. Coatings deposition has been investigated using a multiple target magnetron sputtering coater and oxidation tests of the coatings have been undertaken. This research was completed in early 2016.

Integrity of Coated Ferritic Alloys under High Temperature Creep and Fatigue (Completed): The overall aim of this research is to investigate the integrity of coated ferritic alloy samples subjected to high temperature exposure and steady/cyclic mechanical loadings. This will result in gaining a better understanding of presently developed coatings and the associated key failure mechanisms, ranking of the potential coatings based on test results and provision of a generic understanding of factors limiting coating service life. Characterising of the substrate and coating material to allow a greater understanding of the physical and chemical properties has been undertaken. A mechanical testing programme has also commenced with creep tests of the uncoated substrate steel. A number of uniaxial and notched bar tests, at a variety of stresses, have been completed for the uncoated material and interrupted tests are being planned for the future. Work has also started on examining the failed specimens to understand the evolution of microstructure during creep and to determine the failure mechanisms.

Biomass Exacerbated Cyclic Oxidation of Steels in Steam (Completed): The overall aim of this research is the development of a model for steam side oxidation growth and spallation both prior to and after the initial spallation event based on laboratory observations in simulated cyclic steam oxidation experiments. This will build on current research at the University of Birmingham investigating/modelling steam oxidation and spallation of austenitic stainless steels. This research was completed mid-2018.

Biomass Co-firing to Improve the Burn-out of Unreactive Coals in Pulverised Fuel Combustion (Completed): The overall aim of this research is to determine for a selection of unreactive bituminous coals the extent to which relatively small emissions of biomass can (i) increase volatile yields and so reducing ignition temperatures and (ii) improve char burn-out. This research was completed late 2017.

Modelling of Biomass Milling (Completed): This study uses data generated by the Milling and Conveyance of Biomass project (described earlier) as a base to investigate and validate modelling approaches. The overall aim of the research is to identify the most pragmatic modelling approaches for use in the energy industry and so understand the implications of milling to biomass choices. The output from this research is a validated model and an understanding of the fundamental science behind biomass milling, with a clear appreciation of the advantages and limitations of the modelling methods. This research was completed late 2017.

Modelling Fireside Corrosion of Superheaters and Reheaters following Combustion of Coal and Biomass (Completed): The aim of this research is to develop a suite of interconnected models to predict the degree of fireside corrosion damage experienced by superheaters/reheaters in coal- and biomass-fired boilers. This project was recruited via the 2014 BF2RA Call and research commenced early in late 2015.

Assessment of Spontaneous Combustion Risk (Completed): The aims of this research are to advance the understanding, diagnostic and predictive capability for detecting self-heating in biomass piles, and for prediction of risk from a knowledge of the biomass type and properties. This project was recruited via the 2014 BF2RA Call and research commenced in early 2015 and was completed mid-2018.

Slagging and Fouling Prediction using an Advanced Ash Fusion Test (Completed): This research aims to develop a novel method to predict the slagging and fouling potential of different types of coal, biomass and blends using an advanced ash fusion test. At present the standard test is subjective and relies on manual observations of ash behaviour. This research was completed in late 2018.

Interpretation of Small Specimen Creep Test and Recommendations on Standardisation of Impression Creep Test Method (Completed): The overall aim of this research is to develop a framework for the implementation of the results of small specimen creep testing for assisting in long-term power plant material performance assessment and component life management. This research was completed in late 2018.

The Performance of High Chromium Creep Strength Enhanced Ferritic Steels: The overall aim of this research is to understand the effect of processing and composition on the long-term performance under service conditions of 11-12 wt.% CSEF steels. Recruited from BF2RA's 2015 Call and research commenced in October 2016.

Additives to Mitigate against Slagging and Fouling in Biomass Combustion (Completed): The aim of this research is to understand, through experiment and modelling, the impact of pfa as an additive in the combustion of biomass in both suspended and fluid bed firing and using the mechanistic insight gained to make recommendations on industrial best practice for minimising slagging and fouling in biomass combustion. Recruited from BF2RA's 2015 call for proposals and research commenced October 2015 and was completed late 2018.

Investigation of Potential of Co-milling Biomass PFA with Coal to reduce NO_x Emissions (Completed): To understand the impact of biomass PFA or FBA as an additive in the reduction of NOx emissions from large-scale combustion of coal. Recruited from BF2RA's 2015 Call and research commenced late 2015 and was completed in late 2019.

Rapid Fuel Evaluation using Image Analysis (Completed): The aim of this research is to develop an image analysis method the can rapidly characterise fuel to predict boiler performance. Recruited from BF2RA's 2015 call for proposals and research commenced October 2015.

Advanced Flame Monitoring and Emission Prediction through Digital Imaging and Spectrometry (Completed): This project aims to develop an instrumentation system for monitoring burner flames and predicting emissions on a multi-burner heat recovery boiler using digital imaging and spectrometric techniques. Research commenced late 2015 and was completed mid-2019.

S-CO_2 for Efficient Power Generation with Energy Storage: This research is evaluating the opportunity for new advanced power generation concepts and performance improvements using alternative fluid cycles (supercritical CO_2 (S-CO_2), molten salts, etc.) for applications in combination with heat storage. The development of these new cycles requires solutions to the coupled challenges of fundamental technology development and systems engineering. The research will address the application and integration of these cycles for a variety of high-temperature heat sources to increase efficiency and the reduction of plant cycling, thus improving the life and reliability of existing power generation assets. Research commenced in October 2017

Prediction of the Synergistic Effects of Degradation and Segregation in Handling and Storage of Wood Pellets for Power Generation: This research aims to produce an holistic model to predict both segregation and degradation through a complete handling and storage chain from port to mill, including belt conveyors, large and small silos, flow into and out of rail wagons and pneumatic conveyors. This is intended to allow the prediction of fines and dust as the operational conditions progress with time (especially storage inventory). Using this, the operator will be able to explore methods to mitigate the difficulties, both in terms of operational philosophy and technical optimisation of the plant. This research was recruited from the 2017 targeted call for proposals and the research started in December 2017.

Formation of Corrosive Compounds from Biomass/Waste Combustion: The overall aim of this research is to assess the formation and impact of corrosive compounds from alternative solid fuel (e.g. biomass and waste) combustion and to compare with corrosive compounds arising from coal combustion. A mix of practical and modelling work will be undertaken. This research was recruited from the 2017 targeted call for proposals and the research started in early 2018.

A Suite of On-line Combustion Evaluation Tools for Boiler Efficiency Improvement: This research project will develop and test a set of on-line diagnostic tools that will improve operation management of a travelling grate stoker fired boiler. Three different (but complementary approaches will be used, namely, an empirical image analysis system, the development of a self-calibrating real time dielectric monitoring system and the development of a computational model for the travelling grate furnace, simulating solid fuel combustion. This research was recruited from the 2017 targeted call for proposals. The start date was delayed pending recruitment of suitable researcher and got underway in October 2018.

A Condition-based Monitoring and Advisory Tool for Utility Boilers: This research aims to develop a methodology that is capable of indicating the impact of fuel diet/blend on the efficient operation of the boiler through the integrated utilisation of in-situ flame measurements and boiler data routinely captured by conventional devices/systems. This research was recruited from the 2018 targeted call for proposals and commenced in January 2019.

Modelling Creep and Creep Fatigue Damage for CSEF Power Plant Steels taking into account variable Ductility and Considerations for Condition Monitoring: The overall objective of this research is establish a framework for residual life assessment of ageing power plant materials and components based on the availability of condition monitoring data. This will include a number of novel developments, through a comprehensive theoretical, numerical and experimental programme. This research was recruited from the 2018 targeted call for proposals and commenced in October 2019.

Biomass Combustion System Technology Development for Multi-fuel Diet: The aim of this research is to develop a sensitivity model to understand the optimum levels of potassium that power plants can handle to maximise the plant availability when using different types of biomass. This project was recruited from the 2019 BF2RA Call and is a 9 month post doctoral study in conjunction with an IAA grant. Research commenced in July 2019.

Energy Storage for Large Biomass Plant Flexibility: The aim of this PhD research is to investigate how generator-owned energy storage systems can work with large biomass plant to aid their flexibility. This project was recruited from the 2019 BF2RA Call and commenced in September 2019.

Low Pressure Steam Turbine Last Stage Blade Durability: The overall aim of this PhD research is improve the fatigue endurance of the martensitic stainless steel materials used in the turbine blade root in a fully predictable/tailored fashion. This project was recruited from the 2019 BF2RA Call and commenced in October 2019.

Biomass Densification for Minimal Drying Energy and Optimised Pellet Quality: This is a 4 year EngD research study. The aim is to develop a novel holistic biomass pelleting process, which will aim to minimise drying energy and improve pellet quality. The sub-tropical environment to minimise energy consumption for drying will be exploited. The potential to incorporate torrefaction and pelleting into one system in conjunction with higher moisture content biomasses will be investigated to reduce drying and transport requirements. This project was recruited from the 2019 BF2RA Call and commenced in October 2019