University Alliance DTA^3
Doctoral Training Alliance

DTA^3 Programme Research Projects Proforma

Partner University	University of Portsmouth
Faculty/School/Department/Research Centres	School of Mechanical and Design Engineering
Supervisory Team: please provide details of first, second, and where relevant, third supervisors for this project, and any external supervisors/advisors, where applicable	
First supervisor	David Sanders https://sites.google.com/a/port.ac.uk/davidsanders
Second supervisor	Giles Tewkesbury http://www.port.ac.uk/school-of-engineering/staff/dr-giles-mtewkesbury.html
Third supervisor	Dr Nils Bausch http://www.port.ac.uk/school-of-engineering/staff/dr-nils-bausch.html
External/industrial supervisor	Dr Andrew Painting at Attis Engineering Dr David Robinson at Cutting Tools Ltd
Contact details for project (for informal applicant queries)	david.sanders@port.ac.uk
DTA Programme(s): please tick which DTA programme(s) this project relates to:	
DTA Energy	
Project title	Making decisions about saving energy in Compressed Air Systems using Ambient Intelligence and AI
Project description: please provide a brief description, using the headings given below, of the project (max. 450 words) which will used as part of the advertising material and will be placed in the public domain**. Please also indicate whether there are any confidentiality/sensitivity/IP issues of the research which should not be made publicly available.**	

I. Scientific excellence

Compressed air systems are expensive and inefficient. Less than one-in-ten energy units become useful compressed air. Compressors are often fully on even if not (*all*) needed.

Research will minimise compressor energy use based on real-time manufacturing conditions (*and anticipated future requirements*).

Co-funded by the Horizon 2020 programme of the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 801604.

Research will combine real-time ambient-sensing with artificial intelligence (AI) and knowledge management (KM) to automatically improve efficiency. Ambient data provides detailed performance information. AI will make sense of that data and automatically act. KM will facilitate information processing to advise humans on actions to reduce energy use.

Recurrent Artificial Neural Networks (ANNs) and deep reinforced-learning will be investigated for use with ambient data to provide detailed performance information for machine learning. AI will ask questions and take automatic action.

There will be three inputs from manufacturing units:

-Ambient intelligence data from sensors.
-Energy consumption measurements.
-Ambient sensing from humans.

Data will be stored within a recurrent ANN for the AI, alongside information and expert knowledge in a Common Store. KM will process the information to provide outputs.

II. Clear aim and hypothesis

The aim of this research is to create new intelligent techniques to save energy in compressed air systems.

III. Methodology and innovations

a. Achieve a breakthrough in energy management of air compressor systems.

The methods will combine shop-floor infrastructure and flexible ambient sensing with AI to monitor the infrastructure and sensors and make automatic decisions to save energy.

b. Use ambient-sensing to monitor performance and environment.

The research work will investigate centralized and distributed automatic leak-measuring, model different sized buffer tanks, and create flexible ambient sensor systems by interfacing to existing sensors and introducing new sensors using wireless technology to monitor consumption, loads and variables.

c. AI.

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The work will involve investigating AI to monitor sensors and environment, make automatic decisions and interact with KM and human users. It will also investigate Case Based Reasoning to provide confidence weightings for Decision Making Systems. It will use statistical machine learning to find data patterns. A KM Map will use answers to questions generated by AI and combine knowledge from ambient-sensing and energy consumption data to create useful knowledge spaces.

IV. Strategic relevance
Climate change, coupled with dwindling North-Sea resources and volatility in oil markets made the UK Government identify energy as a strategic challenge. The UK now has a well-coordinated, strong research community reducing energy in domestic and commercial buildings but the Energy Research Partnership and Research Councils UK recognised that reducing energy use for industrial compressed air systems is less well developed.

V. Interdisciplinarity and fit with relevant DTA programme
Research crosses boundaries between electro-mechanical engineering, computer science, environmental engineering and energy engineering. The work clearly fits within the scope of the DTA Energy.

Lay summary (max 200 words) to be used for reference as part of the selection process where non-specialists are involved

Industry is facing higher energy-costs and needs to reduce financial and environmental impacts of using energy. Government recognised needs to reduce climate change effects and introduced targets to achieve by 2020 / 2050. Air compressors account for >10% of UK industrial energy use. Ambient-sensing and knowledge gathered within manufacturing environments represent untapped resources to optimise energy use. This research project will investigate ambient-sensing with artificial intelligence (AI) for manufacturing units that interact with people to produce detailed awareness. AI will interpret sensors, make intelligent judgements and take automated decisions in real-time. It will evaluate compressed air systems by asking questions such as: "Are hoses leaking?", "Is air needed?", "Does loading need all compressors?", "Can couplings be removed?", "Are compressor sizes correct?".

A knowledge management system will answer questions and automatically provide energy efficiency suggestions. Answers will include: "Use smaller compressor.", "No action.", "Replace filters.", "Investigate.", "Dry system.", "Replace compressors".

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The research will go beyond current practices (*e.g. condition monitoring*) by introducing intelligence and holistic awareness. Data will concern equipment, how manufacturing units are performing, environmental effects, human interactions, and energy consumption. That data will be brought together and used with machine learning techniques to provide intelligent approaches to energy efficiency.
Industrial/Employer placement opportunity please include details, where known, of any external placement opportunities or collaborations available to the student as part of the project
Cutting Tools Ltd and Attis Engineering will collaborate and Cutting Tools Ltd could provide placement opportunities.
International placement opportunity please include details, where known, of any potential international placement opportunities or collaborations available to the student as part of the project
Scientific, economic and societal impact of the project
UK Energy Policy will benefit from reduced energy consumption and carbon emissions. This research will contribute to maximising some manufacturing energy savings. Results could be directly or indirectly relevant to more than 500,000 European SMEs with energy intensive manufacturing processes. The project will also improve quality of life by helping manufacturing companies to reduce their energy use and therefore reduce negative environmental effects such as pollution, emissions and energy price inflation. Energy consumption and CO2 emissions will be reduced and energy use made more efficient. The work is mainly aimed at manufacturers using compressed air and will achieve a breakthrough in energy management. The target audience includes: Industry as users and SMEs with energy intensive processes and vendors of equipment, Industrial Associations, ICT Vendors, and the RTD community. New systems will combine shop-floor infrastructure and flexible ambient sensing with artificial intelligence (AI) to monitor them and make some automatic decisions using machine learning and deep reinforced learning. Finally, knowledge management will be used to reduce their energy use and strategies will be derived to motivate more sustainable behaviour. UK Industry will benefit both from significantly reduced energy use for compressors and, in the longer term, from the development of new energy efficiency systems to reduce energy costs. New ways to improve energy management in industry will be investigated and continuous and accurate information and then knowledge will be provided to optimise energy use, as sensorial information and knowledge are delivered about how subsystems and actors interact. Target outcomes are: new and affordable systems for intelligent and interactive energy monitoring, innovative tools, and energy efficiency models. The new methodology and software will allow manufacturing SMEs to reduce energy consumption by at least 15% to 20%, directly contributing to reducing energy consumption.

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Impact will include the creation of new advanced energy efficiency systems that can be further researched in other academic institutions and which can be developed on a worldwide basis. Overall, the work will help to maintain UK excellence in AI methods and sensor integration and advance research in energy engineering and compressed air delivery.
Additional admissions requirements: please state if there are any specific admissions requirements for this project i.e. subject specific degree qualifications or disciplines, relevant skills, experience etc
Candidates must have a relevant good undergraduate degree in Engineering, Science or Physics, preferably with a good final year project mark. An MSc in an Energy related subject with a good project mark is highly desirable. IELTS 6.5 with no component score below 6.0 or an equivalent English language qualification.

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