Institution: Nottingham Trent University

Unit of Assessment: C16 Architecture, Built Environment and Planning

Title of case study: Sustainable Technologies for Built Environment SMEs

1. Summary of the impact (indicative maximum 100 words)

NTU is helping SME manufacturers of building materials to create new, sustainable, higher quality products with reduced energy consumption and carbon emissions to make the companies more competitive. The impact comes through research that develops SME's critical understanding of complex processes and materials, and through NTU's expertise and support in obtaining grants and external funding to develop and implement new sustainable technologies for higher productivity. Examples in this case study from different SMEs include sustainable product design for low carbon buildings, sustainable materials and design, and sustainable energy.

2. Underpinning research (indicative maximum 500 words)

The underpinning research consists of several strands of research by A. Ianakiev, Al-Habaibeh and Su, all from a civil and mechanical engineering background. These strands were used to assist many SMEs in new product and process development.

- using sustainable materials for SMEs:

During the EU funded CRAFT ST-3378 (1999-2001) project, teams at NTU and Queen's Belfast worked with six SME's from the UK, France and Germany looking into improving the productivity and control of the rotomoulding process. The NTU computer modelling of the rotational moulding process identified a substantial improvement in the process by introducing internal cooling. This model was the foundation of a novel production technique with internal cooling, [1] reducing the rotomoulding processing time by more than 40%, which was proven in real working conditions at Rototek Ltd. During the project, at NTU, in-house knowledge was developed of computer modelling and analysis of the behaviour of thermoplastic materials [2]. This knowledge was used in the modelling and development of sustainable design solutions by incorporating sustainable materials into new higher quality floor panels, structural elements and in rotomoulded panels from recycled plastic for a new flood barrier.

NTU's approach for sustainable design and manufacturing was based on the integration strategy of the hybrid integration system [5], and was developed, by blending sustainability techniques into the product development. These included embedding eco-constraints into product design specification, lifecycle assessment, eco-optimisation, and modular design for enhancing product life, reuse and recycle. This was reflected in the development of a novel LED eco-lighting product, and was further enhanced by the FP7 cycLED project (2012) for expanding LED product life span and integrating eco-design tools into LED-lighting product design [6].

- sustainable systems and processes for SMEs:

Since 1995, Dr. Amin Al-Habaibeh has developed new theories in relation to automated sensor and signal processing selections for processes, machines and systems' diagnostic and prognostic systems with integrated artificial intelligence systems [3]. Condition monitoring has also been used for optimisation and improved machine and product design [4]. The underpinning research has been used to critically understand and design improved systems and products for better sustainability, efficiency, productivity and profitability. This design optimisation process has been developed and transferred in recent years to serve SMEs in many sectors such as district heating, improving buildings performance, sustainable energy generation.

Using the network technique [5], a server-client structure was developed to enable effective communication between the server and mobile devices across different platforms, which were then applied in two Sustainable Construction Innovation Network projects (East Midlands industry-led funding source) projects for remote control and monitoring of air-conditioning (2009-2010) and solar thermoelectric generator systems (2010-2011) and which resulted in novel 'air-conditioning'

and 'solar thermoelectric generator' systems for low carbon buildings. Professor Daizhong Su is returned under REF2014 to a different panel (UoA34).

3. References to the research (indicative maximum of six references)

The publications below are all published in peer reviewed journals. In addition we have put all of them through external and internal reviews, to ascertain quality levels. In addition there are several externally funded projects, through very competitive sources.

1. Lim, K.K., **Ianakiev, A.** & Hull J.B., 2003. Numerical Modelling For Rotational Moulding With Non-Isothermal Heating, *Journal of Plastic, Rubber and Composites: Macromolecular Engineering*, Vol. 32 (10), pp. 421-430.
2. **Ianakiev, A.,** and Lim K. K., 2007. Modelling of rotational moulding process: analysis of process parameters and warpage on cycle times, *Journal of Plastic, Rubber and Composites: Macromolecular Engineering*, Vol. 36 (10), pp. 455-462.
3. **Al-Habaibeh**, **A.,** N. Gindy, 2000. A new approach for systematic design of condition monitoring systems for milling processes , *Journal of Materials Processing Technology*, Volume 107, Issues 1–3, pp. 243-251.
4. **Al-Habaibeh**, **A.,** F Shi, N Brown, D Kerr, M Jackson and R M Parkin, 2004. A novel approach for quality control system using sensor fusion of infrared and visual image processing for laser sealing of food containers, *Meas. Sci. Technol*. 15 doi:10.1088/0957-0233/15/10/008
5. **D Su** and M Wakelam, 1998, 'Intelligent hybrid system for integration in design and manufacture', Journal of Material Processing Technology, Vol. 76 (1998), Elsevier Science S A, pp 23-28.
6. Casamayor, J.L. and **Su, D**., 2013, 'Integration of eco-design tools into the development of eco-lighting products', Journal of Cleaner Production, 47 (2013), pp. 32-42

The following grants provided important impetus for the underpinning research and outputs listed above:

1) ***Project title*****:** **'**myEcoCost: A consumer oriented prototype – forming the nucleus of a novel Ecological Accounting System.' ***Source of funding*****:** EU FP7-ENV-2012 programme, 2012-2015, 440,000 Euros for NTU (total 2,959,800 Euros for 9 consortium members across EU). **Prof. D. Su** Co-investigator, NTU team leader, and leader of WP 'Communications and Network Infrastructure**.**

2) ***Project title***: 'cycLED: Cycling resources embedded in systems containing Light Emitting Diodes'. ***Source of funding***: EU FP7 Eco-Innovation programme (ENV.2011.3.1.9-1, Eco-innovation, Project No. 282793), 2012-2016, 295,596 Euros for NTU (total 4,044,370 Euros for 13 consortium members across EU). **Prof. D. Su** Co-investigator, NTU team leader, and leader of WP **'**sustainable design and manufacture'.

3) ***Project title***: 'Eco-lights: Market deployment of eco-lighting products'. ***Source of funding:*** EU CIP Eco-Innovation programme, 2012-2014, 140,000 Euros for NTU (total 550,000 Euros for 4n consortium members). ***Project consortium***: NTU and three SMEs from Spain and Sweden. **Prof. D. Su** Co-investigator, NTU team leader

4) ***Project title***: KTP 007080, 'Development of sustainable new product and new production method'. ***Source of funding:*** Technology Strategy Board (TSB), £100k, 2009-2011. ***Industrial partner:*** Burgess Architectural Products Ltd., UK. **Dr. A. Ianakiev** Knowledge base coordinator and lead academic.

5) ***Project title***: Exploit the water in abandoned coal mines as an energy source to provide low cost, environmentally-friendly heating and cooling of buildings, ***Source of funding:*** *KTP project* £127k, 2013-2015*,* ***Industrial partner:*** Alkane Energy PLC., UK. **Dr. A. Al-Habaibeh** Principal Investigator

6) ***Project title***: Knowledge Transfer Partnership with Nottingham City Homes, ***Source of funding:*** KTP £48k, *2012-2013,* ***Industrial partner:*** Nottingham City Homes, UK. **Dr. A. Al-Habaibeh** Co-investigator with Dr. Lofti

7) ***Project title***: 'Introduction of sustainable practice by replacing metal components used in the installation of solar PV panels with a sustainable material'. ***Source of funding:*** Future Factory (FF) project, £14k, 2012. ***Industrial partner:*** Enerlux Ltd., UK**. A. Ianakiev** Principal Investigator.

In addition the research in the area of sustainable technologies in built environment resulted in 9 smaller grants of total £140k.

4. Details of the impact (indicative maximum 750 words)

The unit has a strong history of active engagement with many SMEs and nine cases are listed below:

- using sustainable materials for SMEs

(1)) The NTU team developed a novel eco-lighting product in collaboration with Ona Product, an SME from Spain. Its new product is significantly more sustainable and has changed the company strategy for product development and positioning in the market. The CEO of Ona commented "*NTU's support greatly enhanced our capacity in eco-product development and market compatibility*".

(2) Rotomoulded panels from recycled plastic have been produced for the development of a sustainable low-cost flood barrier. A prototype of the flood barrier was built (12 m) at the Lea Marston testing site of the Midlands Environmental Agency, with two demonstrations for a wider audience. The cost of the barrier per metre is 10 times less than an equivalent concrete barrier. The barrier was short-listed for the 2008 Lord Stafford Award for East Midlands. At present the new flood barrier is attracting interest for private properties in Scotland (sources 1 and 3).

(3) A novel small scale wind energy generation device developed at NTU in collaboration with the inventor Heath Evdemon, is the first wind energy product that will be installed in the Peak district (source 4).

(4) Utilising the sustainable product design and manufacturing technology developed by Professor Su, Tianma Co. Ltd, an SME manufacturer of windows for buildings in China, re-designed their products with sustainable features and improved functions. The company CEO stated that '*the technology enabled our product to have new eco-features, and enhanced our compatibility in not only China but also the international market*' (sources 2)

(5) The KTP collaboration with Burgess Architectural Products Ltd. provided the company with the capability to manufacture a unique, higher quality floor panel that could command a higher market value and a profit margin up to eight times bigger than the existing product. The product, made entirely from composite material with no metal used, is under development and part of the company business strategy. A testimonial letter from the company states "*Burgess could not have entertained the development without the support of the University. The effect of this product could transform the Burgess Flooring business*" (sources 2 and 5).

(6) The Future Factory (funded by £1.7m European Regional Development Fund, for SMEs in the East Midlands to improve their environmental sustainability and provide access to leading research) project with Enerlux Ltd. supported embedding of sustainable practices within the organisation, through the replacement of aluminium components used in the installation of solar PV panels with more sustainable ones. Structural components were re-designed based on using a composite material, reducing the carbon footprint and improving the economic sustainability. As the alternative components are two to three times cheaper they will have positive impact on the company PV business. (source 2)**.**

- sustainable systems and processes for SMEs:

(1) With the support of two Sustainable Construction iNET grants, novel 'air-conditioning' and 'solar thermoelectric generator' systems for low carbon buildings were developed, and transferred to two

SMEs, CE Technologies Ltd and European Thermodynamics Ltd. The former system utilises desiccant dehumidification in an air-conditioning unit where water is used as coolant, and, provides an environmental-friendly system for relatively wet or humid areas. The latter system uses solar energy to generate electricity and produce hot water. The techniques enable the SMEs to develop sustainable products which become their new business strategy.

(2) Recently, studies of the effect of some buildings elements on overall energy efficiency for The Nottingham Playhouse (NP) and Nottingham City Homes (NCH) has provided NP with better understanding of the performance of their building and its relationship to occupants' behaviour. The amount of energy that could be saved is estimated to be 30% and the company has obtained £1m funding to implement the changes. Dr. Al-Habaibeh worked with NCH on monitoring occupant behaviour to advise the company on the most efficient measures that could be taken to reduce energy consumption (source 2).

(3) Project Working with Alkane Energy plc to extract heat from flooded coal mines for district heating applications, initial modelling suggests up to 40% improvements in energy consumption and emissions. The system was successfully implemented to heat the company offices in Markham. This resulted in a new business stream for the company and they have set up a KTP with NTU to develop it. The project director at Alkane, commented: "*NTU will provide the academic and technical support helping the company successfully harness the huge potential offered by this concept.*"

5. Sources to corroborate the impact (indicative maximum of 10 references)

1) Professional publications:

2008 (03/2008) Versatile flood barrier that doubles as a walkway was launched, Ground Engineering.

2013 (05/02/2013) Disused coal mines have untapped potential for low cost green energy, Midlands Business News

2) Testimonials:

Testimonial letter from Burgess Architectural Products Ltd. - 19.04.2013
Testimonial letter from Enerlux Solar Solutions Ltd. - 15.05.2013
Testimonial letter from Tianma Co. Ltd, China - 07.11.2013
Testimonial email from Nottingham Playhouse - 08.08.2013

3) Award nomination:

2008 The collaborative work on the flood defence barrier (Innovation Fellowship fund HIRF 302) was short listed for the 2008 Lord Stafford Award for East Midlands.

4) Media publicity - interview:

2012 (01.02.2012) Low-level turbine to be tested in Derbyshire Peak District, BBC East Midlands Today, http://www.bbc.co.uk/news/uk-england-derbyshire-16833204,

2012 (01.02.2012) NTU helps develop new wind turbine, BBC news website, http://www.bbc.co.uk/news/uk-england-16814752.

5) Report:

2011 (22/09/2011), Final report for KTP 007080 (NTU - Burgess AP) graded as "Very Good" by TSB and short listed for KTP Case studies database.