Institution: BRUNEL UNIVERSITY (H0113)

Unit of Assessment: 12 – Aeronautical, Mechanical, Chemical and Manufacturing Engineering

Title of case study: Creating a sustainable London by improving energy-efficiency of the buildings

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

Prof Kolokotroni's research confirming unusually high night-time temperatures in London due to the urban heat island effect, and her recommendations to mitigate this effect, have both industrial and political impacts. As 80% of current buildings are expected to be standing in 2050, her assessment of the environmental benefits of cool roof technologies (highly reflective, well-insulated roofs) have provided affordable and practical solutions for politicians and building engineers: in 2009, the European Cool Roofs Council was launched at Brunel, committing to advocating cool roof products for their impacts on mitigating climate change, reducing the urban heat island effect. In 2010, the Greater London Authority, in the 'Climate Change Adaptation Strategy for London', committed to assessing and promoting cool roof technologies in London.

2. Underpinning research (indicative maximum 500 words)

Since the 1990s, Prof Maria Kolokotroni has been researching the impact of the urban landscape, particularly buildings, on climate change and identifying technologies to mitigate the high temperature. As 80% of current buildings are expected to be standing in 2050, her research has provided affordable and practical solutions for politicians and building engineers.

In 1999 and 2000, Prof Maria Kolokotroni and Richard Watkins (then a PhD student) at Brunel University conducted a monitoring programme in collaboration with the Building Research Establishment – an independent research organisation for the built environment sector – which measured the air temperature in 78 locations in the Greater London area for 18 months including two summer periods.

The research findings showed that London had been experiencing the Urban Heat Island Effect – significantly higher temperatures in the city centre, especially at night, than in the surrounding rural areas. This night-time warming is mainly caused by high thermal mass materials used in buildings and lack of vegetation. The high temperature in buildings in London can cause discomfort for everyone, and increases health risks for the vulnerable in particular. This leads to higher demands of energy for air cooling which is a major contributing factor of global warming. Prof Kolokotroni's database, which quantified the environmental impact of buildings in London, was the only contemporaneous database and is still in use today to build a forecast model for the likely air temperature in a particular location in London. [Ref 4 in section 3]

In response to the research, the Greater London Authority (GLA) in 2003, subsequently supported further research to evaluate the effect of the Urban Heat Island Effect on buildings' energy demand and investigated strategies to mitigate the effect on buildings and cities. The findings, along with recommendations for policy makers to mitigate the Urban Heat Island Effect, have been incorporated in a publicly available report, 'London's Urban Heat Island: A Summary for Decision Makers', published by GLA in 2006. In the same year, her recommendations and research were published in the Chartered Institution of Building Services Engineers Guide A which is the prime source of expertise for sustainable development for building engineers.

In 2007, Prof Kolokotroni was awarded an EPSRC funded project – the Development of a Local Urban Climate Model and its Application to the Intelligent Development of Cities (LUCID) – as a principal investigator along with researchers from University College London and the University of Reading. The database was further developed by Prof Kolokotroni and Dr R Giridharan (then a research fellow) at Brunel University in 2007-2008 in order to understand how the physical characteristics of London had caused the high nocturnal temperature. The database was used to validate other forecasting models (developed by LUCID partners, University of Reading, Arup and ADMS-Cambridge) in 2009 and 2010. In 2012, the database and the forecast model developed at Brunel populated the quantitative data to examine the effect of future climate change on the energy demand of the buildings in urban areas.

Prof Kolokotroni in 2009 began to apply the database and forecast model to validate the effectiveness of the 'cool roofs' technology – roofs made of materials which effectively reflect the solar radiation and release the absorbed heat thereby keeping the roofs cool – as a strategy to mitigate the Urban Heat Island effect at a local level. The research proved that cool roofs can improve the thermal comfort by an average of 2.5˚C, reducing the energy demand by 6-7%. As the only UK academic representative, along with GLA as the policy maker, the EU funded project 'Cool Roof in the EU' led to the launch of the European Cool Roofs Council (hosted at Brunel University), a not-for-profit organisation.

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

References:

1. Watkins R, Palmer J, Kolokotroni M and Littlefair P, (2002). *The London Heat Island – results from summertime monitoring*, Proc. Chartered Institution of Building Services Engineers, Series A, Building Services Engineering Research &Technology, Vol (23). No 2 pp97-106. http://dx.doi.org/10.1191/0143624402bt031oa
2. Kolokotroni M and Giridharan R, (2008*). Urban Heat Island Intensity in London: An investigation of the impact of physical characteristics on changes in outdoor air temperature during summer*, Solar Energy Vol 82, pp. 986-998. http://dx.doi.org/10.1016/j.solener.2008.05.004
3. Kolokotroni M, Zhang Y and Watkins R, (2007), *The London Heat Island and building cooling design*, Solar Energy, Vol 81 pp 102-110. http://dx.doi.org/10.1016/j.solener.2006.06.005
4. Kolokotroni M, Zhang Y and Giridharan R (2009), *Heating and cooling degree day prediction within the London urban heat island*, Series A, Building Services Research and Technology, Vol 30, No 3, pp183-202. http://dx.doi.org/10.1177/0143624409104733
5. Kolokotroni M, Gowreesunder B and Giridharan R, (available on line, 2011). *Cool roof technology in London: an experimental and modelling study,* Energy and Buildings. http://dx.doi.org/10.1016/j.enbuild.2011.07.011
6. Kolokotroni M., Ren X., Davies M., Mavrogianni A (2012). *London's urban heat island: impact on current and future energy consumption for heating and cooling*. Energy and Buildings, Vol 47, pp 302-311. http://dx.doi.org/10.1016/j.enbuild.2011.12.019

Research Grants:

7. Building Research Establishment Ltd, (1998-2001). The impact of the urban environment on the energy used for cooling buildings, £21,000 + equipment to the value of £10,000.
8. EU Altener Programme, (1999-2002). Development of strategies for the efficient use of solar and passive ventilation of urban buildings, £17,200, (co-ordinator).
9. EU Altener Programme, (2001-2003). Passive solar heating and cooling, £21,780.
10. EU ASIA-LINK Programme (2005-2008). A Multidisciplinary Approach to Curriculum Development in Sustainable Built Environment, Total value €460,723 (Brunel received £33,500)
11. EPSRC (2007-2010). The Development of a Local Urban Climate Model and its Application to the Intelligent Development of Cities (LUCID) – £179,953
12. CoolRoofs (2009-2011), Cool roofs in the EU, EU – Intelligent Energy Europe programme; €40,800, (www.coolroofs-eu.eu)
13. USE Efficiency (2009-2012), EU – Intelligent Energy Europe programme- €111,750, (www.useefficiency.eu)
14. E-BITS: Young People and Media for Low Energy Footprints (2011-2013), EU – Intelligent Energy Europe programme; €138,336, (http://www.energybits.eu/)

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

By guiding professionals to proven sustainable technology – cool roofs – Prof Kolokotroni's research contributed to establishing an organisation which has been continuing to advocate for and lobby cool roof products based on her research findings.

In 2009, the European Cool Roofs Council (http://www.coolroofcouncil.eu/) was launched at Brunel University, committing to advocating cool roof products for their impacts on mitigating climate change, reducing the Urban Heat Island effect and thereby contributing to creating a sustainable urban landscape. Prof Kolokotroni's research on identifying the Urban Heat Island effect in London and verifying the environmental benefits of cool roof technologies has been essential to the establishment of the Council. The European Cool Roofs Council, a not-for-profit European association, is now proactively lobbying national and European legislative organisations for the inclusion of cool roofs as a mitigating strategy for cities; for example, in Greece, the national building regulations specify the inclusion of cool paints for all new public buildings. In the UK, cool roofs are considered for inclusion in BREEAM. The Council has also standardised cool roof materials by developing a strict Product Rated Programme which informs users – code bodies, architects, building owners and specifiers – of radiative property values under the Programme. The Council members include multi-national industry members such as Monier Group (roof construction materials), Daikin (air-conditioning equipment) and Dow (construction chemicals), government agencies, educational institutions, energy service companies, etc. across Europe and it has direct links to its US equivalent, the US Cool Roof Council (http://www.coolroofs.org). Prof Kolokotroni is a board member of the technical committee and the Rating Scheme Certification Committee.

In 2010, GLA first published the 'Climate Change Adaptation Strategy for London' which was updated in 2011. The strategy commits in Action 5.10 that 'the Mayor will work with partners to assess and promote "cool roof technology" in London to reduce demand for mechanical cooling' (p67). The European Cool Roofs Council was specifically stated as the partner for this action (p113). (http://www.london.gov.uk/sites/default/files/Adaptation-oct11.pdf)

These demonstrate how Prof Kolokotroni's research on the Urban Heat Effect in London and how to mitigate it has reached beyond the academic community, contributing to creating more sustainable urban communities by working with government and industrial partners.

Prior to this project, her long-term research on the Urban Heat Effects in London and how to mitigate the phenomenon has alerted GLA and building professionals:

Her development of several methods and models for calculating the local temperature in urban areas has informed building professionals and policy makers that the heat received, generated and trapped in the urban areas increases the local temperature (i.e. the Urban Heat Island Effect). Consequently, this increases the energy demand necessary for reducing the high temperature, hence increasing carbon emissions and contribution to global warming; it is also known to affect health. The research on the Urban Heat Island Effect was received with keen interest from policy makers, raising their awareness: in 2008, GLA acknowledged the Urban Heat Island Effect in The London Plan (4.31-4.32).

The London Plan (2008) was soon replaced by a newer version of the London Plan in 2011, which more extensively and concretely lays out its strategies to deal with the Urban Heat Island Effect: it states that it aims to 'address issues of environmental quality raised by the urban heat island effect' as one of its 'strategic priorities' (p50) and that 'The Mayor seeks to reduce the impact of the urban heat island effect in London' (p144) and endeavours to avoid 'internal overheating and contributing to the urban heat island effect' in its future design and construction plans (p136).

Prof Kolokotroni's research also had impacts on building practice, through widening awareness amongst building professionals of the Urban Heat Island Effect. Her research results from 1999 to 2000, which measured Urban Heat Island intensities, were directly incorporated by the Chartered Institution of Building Services Engineers (CIBSE) into their latest publication of the CIBSE Guide A: Environmental Design (Section 2.10) (2006). The Guide serves as the primary source of information for building professionals to introduce the latest research and best practice in environmentally sustainable design, and it is still current. Using this information, designers can take the higher temperatures in the city into account in their designs, thus reducing carbon emissions

from their building while maintaining comfortable conditions for people.

In addition to its industrial and political applications, in 2013, the research helped Energy-BITS (http://www.energybits.eu), in collaboration with media production companies, develop games, competitions and documentaries in order to raise awareness of energy use for youth (aged 14-18) The website can be viewed in 9 languages. Similarly, in 2012, the research contributed to establishing the Universities and Students for Energy Efficiency Association (http://www.useefficiency.eu) which aims to improve energy efficiency in university buildings and provide training programmes for students by bringing together universities and companies across Europe. The Association has organised two summer schools – one of these in London during the Olympics.

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

(1) The Mayor's Climate Change Adaptation Strategy (2011)

http://www.london.gov.uk/sites/default/files/Adaptation-oct11.pdf

See p67 '**Action 5.10.** The Mayor will work with partners to assess and promote "cool roof technology" (highly reflective, well-insulated roofs) in London to reduce demand for mechanical cooling'; also see p114, Action 5.10 European Cool Roof Council is specifically stated as the partner for this action.

(2) London's Urban Heat Island: A Summary for Decision Makers (2006)

http://static.london.gov.uk/mayor/environment/climate-change/docs/UHI_summary_report.pdf

Brunel University is stated as one of the contributors to the report (under copyright).

(3) President, European Cool Roof Council

The contact can corroborate the research impact on the establishment of the European Cool Roof Council and their work.

(4) President, Universities and Students for Energy Efficiency Association

The contact can confirm the research impact on the establishment of the Association and their work.