**Institution:** Oxford Brookes University

**Unit of Assessment:** 16 - Architecture, Built Environment and Planning

**Title of case study:** DECoRuM®: an innovative Geographic Information System based carbon reduction model

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

Professor Gupta, an internationally recognised expert on architecture and climate change, has developed an innovative software model for carbon counting (DECoRuM® model) and climate change adaptation (DECoRuM® adapt) of existing housing. The combination of Geographic Information System techniques, energy efficiency and climate change adaptation measures has enabled DECoRuM® model to provide a range of environmental, public policy and practice benefits to homeowners, communities, local authorities and architects. These benefits have been realised through refined global common carbon metrics promoted by UNEP, BSI standard and industry guidance, as well as achievement of real energy and CO2 emission reductions from low carbon refurbishment, leading to improved building energy performance.

**2. Underpinning research** (indicative maximum 500 words)

Professor Rajat Gupta (Oxford Brookes University 2005-present) brought together disparate fields of energy modelling and spatial mapping to create the RIBA award-winning (2006) model, the Domestic Energy, Carbon Counting and Carbon Reduction model (DECoRuM®). DECoRuM® brings together Geographic Information System (GIS) techniques (based on MapInfo GIS) and BREDEM-12 energy model, to rapidly measure, model, map, manage and track domestic CO2 emissions on a house-by house level, and also aggregate and visualise results on an urban scale. The background calculations of DECoRuM are performed by BREDEM-12 (Building Research Establishment's Domestic Energy Model - BREDEM) and SAP 2009 (Standard Assessment Procedure-SAP), both of which are dynamically linked to create the model and perform the calculations. To inform the model, actual home characteristics are gathered from historic and current maps, on-site street survey, occupant questionnaires, and literature describing home characteristics based on age and typology. Using such data reduction techniques, DECoRuM is able to assess baseline energy usage and evaluate energy savings, CO2 reductions and cost-effectiveness (using life-cycle costing) of applying best practice energy efficiency strategies and low/zero carbon technologies in existing housing.

In 2006 DECoRuM® was awarded proof of concept funding from SEEDA for its further development; this required applying the model in the city of Oxford and at Arizona State University with a view to their carbon emission reduction. These studies demonstrated that by applying DECoRuM, an estimate of the potential area-based level of CO2 reduction was possible e.g. application of DECoRuM model to a case study in Oxford shows that CO2 emission reductions above 60% are possible, at a cost of between £6 and £77 per tonne of CO2 emissions saved, depending upon the package of measures used and the scenario of capital costs (low or high) employed[1].

An EPSRC CASE award[2] (Robert Irving supervised by Professor Gupta), enhanced the heat-pump sub-model of DECoRuM to assess the possible effects of future domestic heat pump installations on the UK energy supply[3]. Following on from this work, in 2010 through an ESRC-funded research grant[4] 'EVALOC project on evaluating low carbon communities', DECoRuM® has incorporated a 'community energy monitoring toolkit' to track the impact of community-led low carbon interventions on energy behaviours through detailed long-term monitoring of energy use and environmental conditions (visualised through maps).

The DECoRuM model has also been applied to climate change adaptation, through the EPSRC-funded SNACC project[5] which investigates how existing suburban neighbourhoods in England can be 'best' adapted to reduce further impacts of climate change and withstand ongoing changes. 'DECoRuM-Adapt' toolkit was developed and tested to establish the impacts of climate change on both winter heating demand and summer overheating potential of existing suburban homes (in six suburban typologies across Oxford, Stockport and Bristol). Probabilistic climate change projections for 2030s and 2050s were used in dynamic thermal simulation (IES Apache sim) to test the effectiveness of incremental adaptive retrofitting packages in reducing future overheating risk in

typical English home archetypes. Using 'DECoRuM-Adapt' these adaptation packages were further evaluated in the six case study neighbourhoods across the three cities to assist planners and policy-makers in assessing and preventing overheating risk at a stock level. This showed that the existing housing stock must be future-proofed for a warming climate, particularly through retrofit programmes (e.g. the Green Deal) and any upgrading of building regulations [6].

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


1. Gupta, R. (2009). Moving towards low-carbon buildings and cities: experiences from Oxford, UK. *International Journal of Low-Carbon Technologies* (4), pp.159 -168 DOI: 10.1093/ijlct/ctp028

2. EPSRC CASE/CNA/06/82 (2007) 'The potential for heat pumps to reduce energy-related carbon dioxide emissions from UK housing (existing and new) in a changing climate' Student: Robert Irving

3. Gupta, R. and Irving, R. (2013). Development and application of a domestic heat pump model for estimating $CO_2$ emissions reductions from domestic space heating, hot water and potential cooling demand in the future, *Energy and Buildings*, http://dx.doi.org/10.1016/j.enbuild.2012.12.037

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4. ESRC RES-628-25-0012 'Evaluating the impacts, effectiveness and success of DECC-funded low carbon communities on localised energy behaviours (EVALOC)' 2011-2014, £1,144,509

5. EPSRC EP/G060959/1 'SNACC: Suburban Neighbourhood Adaptation for a Changing Climate - identifying effective, practical and acceptable means of suburban re-design'2009-2012, £182,046.

6. Gupta, R and Gregg, M (2013) Preventing the overheating of English suburban homes in a warming climate, *Building Research & Information*. 41:3, 281-300 DOI: http://dx.doi.org/10.1080/09613218.2013.772043

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

DECoRuM model and consequent research projects have had a considerable and on-going impact on defining best practice, identifying changes in household energy behaviours and brought improvements to environmental policy and building practices. The following narrative presents selected examples in support of these benefits.

**Policies and Practice**

In 2008, working in partnership with the GeoInformation® Group, DECoRuM research was used to provide carbon mapping services to UK local authorities. Furthermore, principles of carbon counting research have underpinned the development of several tools, protocols and practices. Professor Gupta, drawing on his research expertise of DECoRuM, through his role as technical advisor, contributed to UNEP's Global Common Carbon Metric tool[7] and protocol through the Sustainable Buildings and Climate Initiative. The Common carbon metric protocol is currently being developed as an ISO standard on carbon metric of building (ISO/TC 59/SC17)[8]. Principles from carbon counting research have also been applied to development of the world's first carbon neutrality standard, through Professor Gupta's contributions as member of the steering committee, the British Standards Institution's (BSI) 'UKPAS 2060 Specification of the demonstration of carbon neutrality' [9](taken up by nearly 100 organisations).

**Community engagement**

Through the EVALOC project[4], DECoRuM incorporates a 'community energy monitoring toolkit', designed to present results on impacts and effectiveness of low-carbon interventions. A

'community engagement toolkit' is also included which provides usable materials and guidance for community energy projects: nationally through monitoring and evaluation of six case study low carbon communities funded through the Department of Energy and Climate Change's Low Carbon Communities Challenge programme; and locally through the steering group membership of the Low Carbon Oxford initiative since 2012[10].

More recently, through the DECC-funded Local Energy Assessment Fund (2012)[11], DECoRuM has enabled a local community in Bicester (Oxfordshire, UK) to prepare for the National Green Deal programme, by assessing the potential for applying costed refurbishment interventions (packages) based on a combination of best practice energy saving measures, and low carbon technologies. Findings from the DECoRuM-Bicester model have been directly used to install cavity and wall insulation in 42 dwellings, resulting in $CO_2$ savings of least 50t$CO_2$ per year[12]. To share insights from carbon counting research, since 2013 Gupta has been appointed a steering group member of the Department of Energy and Climate Change's English Housing Survey (EHS) Modelling project.

**Future proofing and designing for the future**

SNACC project assessed the risk of climate change driven overheating for existing suburban homes[5]. The effectiveness ranking of interventions for tackling overheating in homes[6] have been explicitly applied in Department for Communities and Local Governments seminal report, published in 2012, 'Investigation into overheating in homes'[13]. The report, citing Professor Gupta's research directly, identifies policy instruments to tackle future overheating in new build (Building Regulations) and refurbishments (National Green Deal advice). Furthermore, overheating findings from SNACC research project have been taken up and disseminated through a National Overheating Guidance note[14] prepared by United Kingdom Climate Impact Programme (on behalf of Department for Communities and Local Governments) with endorsement from the Green Deal Oversight and Registration Body in addition to Department for Energy and Climate Change. This guidance note will be distributed to all Green Deal advisors and assessors. In addition to these, UK's Adaptation and Resilience to a Changing Climate Coordination Network (ARCC-CAN) has taken up SNACC's research findings on overheating to produce a detailed guidance note to underpin the National Overheating Guidance Note [15].

Impacts from DECoRuM-adapt model are continuing to be realised through Professor Gupta's continued engagement with industry and communities of interest. Since 2010, the risk-based methodological approach developed in the SNACC project has been successfully applied in five Technology Strategy Board-funded 'Design for future climate' projects with nationally leading architectural practices and consultancies e.g. Farrells, BDP Partnership, Medical architecture, Penoyre and Prasad LLP, and Ridge and Partners. The projects have systematically evaluated, through downscaling of UK climate change projections and simulation, the potential for incorporating adaptation strategies for tackling overheating into live designs of future low/zero carbon homes, schools and hospitals in the UK. In particular, findings from one of the Design for future climate project on future-proofing NW Bicester eco-town, has led to the introduction of a new local planning requirement for developers by Cherwell District Council, related to testing of new housing for overheating in 2050s[16].

**Achieving real $CO_2$ emission reductions**

The approach of DECoRuM carbon counting research has also been applied in advanced low carbon refurbishments of three TSB funded Retrofit for future projects (by Oxford Brookes University) out of which one project (Oxford Whole House Carbon Reduction) has achieved 80% carbon emission reductions in reality (wide media coverage) and is the only case study profiled by TSB in their Retrofitanalysis report[17].

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

7. Phase 1 and Phase 2 reports for Global Common Carbon Metric protocol (2011 and 2012) http://www.unep.org/SBCI/pdfs/Final_Report_PhaseI_Pilot_CCM_140910.pdf ;copy of Phase 2 report available upon request.
8. ISO/TC 59/SC17: Environmental performance of buildings - Carbon metric of building in-use stage

http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=322621
9. British Standards Institution's (BSI) '*UKPAS 2060 Specification of the demonstration of carbon neutrality'*. (Oxford Brookes University is mentioned as the only University on the steering group committee)
10. Gupta, R., Barnfield, L. and Hipwood, T., (2013) Evaluating the impact of low carbon communities on household energy behaviours, *PLEA2013 - 29th Conference, Sustainable Architecture for a Renewable Future, 10-12 September 2013*. *Munich, Germany. Also see: www.evaloc.org.uk*
11. Gupta, R. and Cherian,R., (2013) Mapping communities and neighbourhoods for local carbon reductions, *European Council for an Energy Efficient Economy (ECEEE) 2013 Summer study proceedings*, 3-8 June, 2013, Belambra Les Criques, France.
12. Corroborating contact 1. Bioregional Development Group (2012) Final report on LEAF.
13. Department for Communities and Local Governments seminal report, published in 2012, 'Investigation into overheating in homes' 3.13, 3.28 www.gov.uk/government/uploads/system/uploads/attachment_data/file/7604/2185850.pdf
14. 'Overheating in homes: Advice and evidence from the latest research' ARCC, UK Climate Impacts Programme, February 2013; http://www.arcc-cn.org.uk/wp-content/pdfs/ACN-overheating-guidance.pdf
15. 'Synthesised advice on identifying and preventing overheating in homes under the Green Deal'; ARCC, UK Climate Impacts Programme, April 2013 http://www.arcc-cn.org.uk/wp-content/pdfs/ACN-overheating-and-green-deal.pdf
16. Corroborating contact 1. Cherwell District Council's Local policy requirement on overheating, Bicester Eco-town Programme Manager.
17. Technology Strategy Board (2013) *Retrofit revealed*. http://www.retrofitanalysis.org/retrofit-revealed-by-technology-strategy-board.pdf