Introduction

There are many initiatives considering the sustainable house construction, though none consider driving such initiatives, ideas and practices into the construction and allied industries supply chain. The University of Salford's Salford Centre for Research & Innovation (SCRI) based in the U.K. has set up a research project that will meet these requirements. The study funded through SCRI by the Engineering Physical Science and Research Council (EPSRC) aims to transfer knowledge, encourage and alter stakeholder mindsets in readiness for the proposed seamless delivery of the sustainable house construction. This paper outlines the intended research methodology and framework that is required to meet the accelerating housing challenge taking place in the U.K. at present. The study recognizes the definition of the sustainable home in conjunction with the British Broadcasting Company (BBC) in the U.K. as:

"Sustainable housing is a form of affordable housing that also incorporates environmentally friendly and community based practices. It attempts to reduce the negative impact that homes can have on the environment through choosing better building materials and environmental designs."

This definition informs of the social, economical and environmental issues relevant to the sustainable house construction project. Where these three elements come together in modern sustainable house construction it is known as the 'triple bottom line' further defined by Bruntland (1987). Furthermore the Department of the Environment, Transport and Regions (DETR) (2000) requested in the year 2000 that the triple bottom line be integrated in the area of what is described as the strategic regeneration program of works. Housing has been a concern in research and development establishments in the U.K. for many years. Already there has been relevant work undertaken including that of the Building Research Establishment (BRE) based in the U.K. The study will undertake a thorough literature review and other methodology in order to capture and evaluate these past studies findings and outcomes and where feasible use them as knowledge strains in the production of a sustainable house model. Not all will be relevant as the study proposes to suppose housing as a service as opposed to a product as is traditionally perceived. The mechanism for delivering this service will use the form of a matrix model and framework for change known as 'G-Tech' for Green Technologies.

Drivers for Sustainable House Construction

In order to achieve this, the study will take into account the present drivers for sustainable house construction. The obvious include policy drivers outlined further below, building regulations and other statutory requirements. However in the ever changing world the global community are more recently concerned about rising

temperatures, melting ice caps, global warming and the green house effect as described by Gilkinson et al (2005). Some scientists believe that the global warming effect has occurred through human impact as we tip the balance through mass industrialization, pollution and rising CO2 emissions from everyday life. Domestic houses in use are responsible for 40% of total CO2 emissions in the U.K. as detailed by Boardman et al (2005). Other drivers are demand caused not necessarily from a population explosion but rather a change in household culture coupled with an aging population. Finally a political and economical driver is that the new build housing be of an affordable nature and available to those who wish to settle in their particular region. This is a problem as desirable areas attract money that push up house prices that affectively out price the local people.

Policy Drivers

Recent reports have been concerned with the design and construction of homes in the England and the United Kingdom. Technologies and production innovations such as off site manufacturing (OSM) and other modern methods of construction (MMC) are required to improve efficiency of the housing market as outlined by the Department for Communities and local Governments report: Design for Manufacture (2006). Also recommendation 33 of the Barker Review (Barker, K 2004) for Housing Supply stated that the House Builder's Federation and the National House Building Council (NHBC) should develop a strategy to address barriers to the introduction of the MMC to mainstream house construction activity that may require a change at policy level as well as a change to relevant building regulations. These barriers do not consider the softer issues and people barriers. This study will capture the importance of trust, loyalty and efficient communications in the successful deployment and construction of the sustainable house. Here the people issues will gain authority as the sustainable house is transformed to the service produced through the proposed G -Tech model.

Furthermore the Office of the Deputy Prime Minister (ODPM) states that 'There are useful policies and programs for sustainable housing, but these are inadequate, not linked to each other and their effects are limited in relation to the scale and urgency of the challenge'; highlighting the fragmentation of the housing project. In addition the Department for Food, Environment and Rural Affairs (DEFRA, 2004) claims that 'there is a poor record of compliance with the design standards and a dearth of data on the real-life performance of new homes' and that there is a need for multi level systems, tools and techniques for producing a 'holistic service in use' for both public and private sector housing projects. The G-Tech model intends to provide this 'holistic service in use' through a seamless delivery innovation.

The research study has selected housing as the core to its importance to the U.K. economy. According to the DTI Construction Statistics (2006) the housing market in Great Britain excluding the Northern Ireland in 2005 brought in £21.064 billion for new house construction amounting to 35.4% of all new build. In refurbishment,

repair and maintenance works that amount was £23,938 billion taking up 50.29% of all such works. This amounts to an overall 42% of all construction output in Great Britain and proximately the U.K (including Northern Ireland). This is a significant chunk of the 8 – 10% of gross domestic product (GDP) that the construction sector produces in the U.K. However this amount may be more when one considers Barretts' Revaluing Construction Report (2005) that includes within the full construction life cycle; all procurement activity including design and facilitates management. This boosts the GDP to roughly 20% emphasizing the necessity for further research in the area of sustainable house construction.

Household Culture and An Aging Population

In the U.K. as pointed out by the HM Treasuries Housing Policy: An Overview (2005) there is a change in household culture and family relationships as more couples live apart for various reasons. Due to this the increase in demand for houses outweighs the increase in population with Barker (2004) estimating a 30% increase in the housing market. Also in the U.K. there is an aging population as fewer children are born and through better medical research people live longer. That does not mean however that the demand is shared equally across the U.K. regional borders. In fact in South East of England there is a decline in population but in the North East there is an increase due to regional industrial activity. The G-Tech model will consider such elements as the housing 'service' proposed provides better planning to suit regional activity.

Housing Supply and Demand

Presently as reported by the Communities and local Government Housing Statistics (2006) report in 2005/2006 in the U.K. 213,000 houses were constructed increasing by approximately 10,000 from the year previous. According to Barker (2004) there is a requirement for 230,000 affordable houses per year until 2016. There are estimates for the expected shortfall and forecast for the amount of housing required with Best and Shucksmith (2006) predicating a shortfall of one million by the year 2022. Therefore the need for better house construction is imminent. Recognizing that the locality of the housing market per region has an effect; in response the U.K. government call for housing frameworks to be developed to suit each area. This highlights the interconnectivity of the varying drivers for sustainable house construction; all to be included within the development and evolution of the research project.

The Reduction in U.K. Skills Base

A very important element of the housing equation to consider is the lack of skills in the U.K. asked to meet economic requirements and such demand. At a time when initiatives such as modern methods of construction (MMC) have been introduced the

reality of it is that there is not enough workforce to provide the service needed. Also the existing workforce does not consist of those who are qualified to work with the innovative construction systems available. The G-Tech model will consider such new initiatives and the lack of skills base and likewise recognize these knowledge strains in its development. There are 140,000 people who make up the skills base at present with a forecasted reduction to 106,000 by 2016 (Housing Forum (2002). The proposed study will in essence describe how the declining skills base can be rejuvenated.

Houses in Use & CO_2 Emissions

At present there projects underway in the U.K. concerned with reducing CO2 emissions in house construction and domestic housing in use; such as the Engineering Physical Science and Research Councils (EPSRC) 'Green Houses for the Future'. This project considers what the end user stakeholder can achieve to reduce CO2 emissions; it is understood that such emissions can be reduced by a third just by tackling energy inefficiency in dwellings and thus reduce global warming and the greenhouse effect as outlined by Sigmond et al (2003). Policy in the U.K. as reflected in the Department for Communities and Local Governments publication 'Building a Greener Future: Towards Zero Carbon Development' (2006) report that houses will generate zero CO2 by 2016. The reasons for the poor use of energy by end users are unclear. Though it can be perceived that the problem may be partly cured by informing relevant stakeholders of the cause and effect of the improper use of the building envelope has upon the natural environment. Though such communications incorporated within the proposed model will encourage 'buy in' to counter the global warming situation. There are other initiatives underway such as the Carbon Reductions in Buildings (CaRB) described by Shipworth (2006), dedicated to cutting down carbon emissions from buildings as described by Lomas et al (2006). Regarding standardization, BRE EcoHomes are providing the first measurement through their 'SAP testing', where a pressure test ensues to establish the air tightness of a dwelling and produce a carbon rating as explained by Rao et al (2003); this applies to both new build and existing stock. Linked to existing stock is the Technology Assessment for Radically Improving the Built Asset Base (TARBASE) described by Peacock et al (2005) dedicated to bringing stock up to acceptable standards. Again these projects will all be considered and their discoveries used in the formation of a working G-Tech model.

The Salford Centre for Research and Innovation (SCRI) & Sustainable Housing

The University of Salford's SCRI have already gotten involved in the sustainable housing research agenda. They have already developed the 'process' models for six different types of housing providing costing exercises. In addition members of SCRI

have made contributions to policy networks such as the Office of Government Commerce (OGC) Construction and Facilities Management Units' and the OGC Housing Efficiency Forum North West. In addition the SCRI centre links regionally with various regeneration solutions such as the New Heartland Housing Market Renewal (HMR), Elevate which is East Lancashire's Housing Market Renewal, Manchester's HMR including Manchester City Councils Decent Homes Housing Framework that considers the incorporation of standard comforts with modern technical installations by 2010. Other links include organizations based in the North West including First Choice Homes, Harvest Housing Group, Helena Housing, St Helens Council, CDS Housing, LHT Housing and Fusion 21 that focus training capabilities to MMC consolidating demand across contracts. These organizations will be invited to get involved in the research project. Also, SCRI members have made significant contributions to the National Audit Office's 'Using Modern Methods of Construction to build Homes more quickly and Efficiently' report (2005). In addition the centre has good stead and a history of working in the areas of process (Lee et al 2000) and design (Tzortzopoulos et al (2005).

All of the above forms good grounding and a working platform to move the project forward from a conceptual model to a working one. The development of the G-Tech model will capture all the relevant information in order to provide a one stop shop systemic mechanism to deliver better more efficient local environment friendly housing.

The G-Tech Model

The above outlines the SCRI centers' intentions to develop a systemic model considering the drivers including the triple bottom line, an aging population, demand and the need to reduce CO2 emissions for more efficient sustainable housing. Part of the research will be to provide a holistic service in use and seamless delivery for the sustainable house 'service'. More specifically the model will require the integration of all relevant stakeholders as outlined by Khalfan (2004) to produce the best design per region considering facilities management and the life style of individuals and where relevant their changes in lifestyle. Also the model will consider future community arrangements dealing with the integration of immigrants, environmental preservation and better energy efficiency. In response to Barker (2005) the project will embrace the best use of space, resources and technology as well as selecting the right house for the right time for the right area. Research at Salford have to date tagged modern housing in three categories: the fully automated technological house, the ecological house made from a range of features including pre assembled components, and a lifestyle house that changes to suit the owner's present well being. Undoubtedly these categories will be further considered in this study.

Further consideration will be given to the durability, permeability and buildability of defined material resources, the structures fixity, structural stability and acoustic attributes taking into consideration the strain on planetary resources outlined by Meadows et al (2004). For it is more sustainable to use renewable material resources such as timber though only if from sustainable forests as outlined in the Forest Stewardship Councils' (FSC) UK Working Group Report (2006). Using resources efficiently is one thing, using them without waste is another. That is why the study will pull on expertise achieved in the SCRI centre on efficient practices outlined by Henrich and Koskela (2006). It is the intention of the study to provide this information along with relevant regulatory requirements including land fill tax and policy aimed to preserve the natural environment. This will encourage the stakeholder to look upon the sustainable house, not just as a service but as a responsibility.

Finances have great impact on whether a green technology strategy or innovation is used in the mainstream UK construction industry. Therefore it is necessary to consider the cost of new alternative sustainable technologies and compare to those practices of the traditional equivalents. It is understood that usually these innovative technologies are more expensive due a lack of demand, highlighting the problem with change in the industry as employers back away from new working techniques distant from their usual procedure.

It can be perceived that broad social elements of sustainable house construction will be met through innovative design solutions leading to social and environmental improvements. Other social responsibilities to be considered include the safety of the workforce and present strategies used in communication with the local community. Also consideration will be dedicated to assess the effect of such design on people and the distinction between what is prescription and what is reality, as far as the proper use and understanding of the sustainable technology and product is concerned.

Developing G-Tech

The above outlines the need for the development of a systemic, evolutionary innovative research agenda for sustainable housing. In the conceptual stages of the project discussions lead to the decision that the study should challenge current thinking and investigate the prevailing focus that houses are 'products' and suggest that housing be considered as a 'service'. Therefore moving away from the 'static, discrete' product solution to a 'dynamic, systemic' solution based on whole life cycle co-production between the supply and demand sides. In order to provide this service there is a requirement to consider procurement and the socio-technical system innovation-industry, organization and or project. Therefore the service should be delivered without hindrance, miscommunication or resulting non conformance of elements of the finished building envelope. This is the development of a service not only systemic in nature but seamless in delivery.

The overall objectives of the project are:

- To develop a systemic understanding of, and interaction between, the demand and supply systems of sustainable housing.
- To develop multi-level, multi-actor innovation frameworks, processes and tools to ensure evolutionary, sustained improvement in the articulation of need, design, production and use of sustainable housing.
- To develop a self-funded (non-IMRC) SCRI 'Sustainable Housing Research, Information and Consultancy Centre' by 2011

In order to understand the strengths and weaknesses of current house construction practices in the U.K. the program of research will review and identify the use of 'green technologies' in the UK housing sector. It will be necessary to attend conference, seminar and other events that highlight or promote the sustainable house construction. Those practices that synergize efficiency and waste reduction will be recognized and mapped against the triple bottom line for consideration by the G-Tech model for the sustainable home. The systemic mechanism will need to detail the following in order to provide the seamless delivery of housing as a service.

Product Innovation Process (design)

The study will explore the mechanisms for applying green technologies to UK housing and identify the barriers to adoption throughout the construction project supply chain. The model will establish methods for aligning government policy in practice via archives of information made readily available to the stakeholder decision makers and specifiers. This will reveal long term needs and suggest appropriate transfer and diffusion frameworks and processes to encourage the adoption and use of 'green' technologies (G-Tech). This will challenge current thinking regarding the limited diffusion into stakeholders mindsets with the intent to better the housing design and construction processes.

Process (Design) Innovation

Here the program will attempt to develop better briefing mechanisms with the help of past studies on process and innovation undertaken in the University of Salford. This applies to the strategic 'deploy' and 'adapt' parts of the systemic model (shown in Fig.2) considering also 'holistic service in use' processes. Such strategy will enable the mechanism to provide better sustainable and 'green' technology for use within the construction project. This part of the model aims to encourage the manufacturing and construction supply chains of the supply chain to fully integrate in line with the sustainability agenda outlined by Fairclough (2002).

Process (Production) Innovation

This part of the model will establish the SCRI Centre as a knowledge broker in the transference of government policy and sustainable housing strategy to the construction stakeholder and housing developer. Here motivators and incentives for the adoption of green technologies will transpire inspiring sustainable housing specification and material and product development. Such information will be transferred via diffusion frameworks from the G-Tech model used to encourage the appropriate adoption and use of MMC, OSM and other good construction site practices. Here it is necessary to investigate and map key organizational and people barriers to the adoption of environmentally effective housing production methods. It is understood that technology is instrumental to the production of the environment with people the catalyst and consumer. Therefore without the right people getting involved the system will not work properly.

Each of the above elements of the 'seamless delivery' for housing package will be developed to integrate solutions for sustainable housing that have a positive effect on society, institutionalized and governmental policy and in turn U.K. best practice in social housing. Such integrated activity providing organizational improvement will cluster business strategy, market positioning and people to form a synergy for improvement and generic best practice in housing project development and construction. It is understood however that for G-Tech initiative to take hold the housing company/organization will and should adopt sustainable technologies. For without company adoption society may never adapt and change to sustainable practices. The strategy for the introduction of better more efficient technologies will consider what a company knows and what it can do rather then the products it has and the market it serves. Such technical strategy centers on this knowledge consisting of policies, plans and procedures for acquiring knowledge and abilities.

G-Tech Program of Research - Method

In order to understand the interaction and relationship between the demand and supply systems for sustainable housing in acknowledgement to the first objective it is necessary to identify the current use of green technologies and mechanisms in the UK housing market. Once identified they will be analyzed for sustainable criteria for social, economical and environmental impacts with further consideration given to the weightings and methods of measurement already used, and their validity for use within the G-Tech model. During the information capture in order to establish the sustainable strengths of the technologies various supply chain stakeholders will be contacted including residents, contractors, house developers, registered social landlords and others. Also during this stage the stakeholder perception will be considered. For example, due to a moral obligation one may find that a sustainable water supply is located on a property. That does not mean however that the system is

used. If not, why? Is the system inefficient or are the owners too use to the comforts of their main water supply? The housing 'service' supplied through G-Tech will encourage and inform of the benefits of such technology and their consequences; encouraging 'buy in' and the change required.

Literature reviews will take place to establish the current pressures upon the ecological system through the inefficient design and construction of housing. It is perceived that issues of interest will include supply and demand, economies and markets, government policy, regional policy and the barriers to the successful adoption and incorporation of sustainable housing. Such barriers may include the ignorance of the construction stakeholder and end user regarding sustainable innovative best practice. Here methods will consider the inadequate process and alignment of policy throughout the construction project supply chain, the misinterpretation of policy at local level and the depletion, consumption and regeneration of natural resources.

Industry collaboration is essential in order to achieve the required knowledge transfers. When the model is complete it will be piloted on a housing case study. Once constructed the system will enforce a post occupancy valuation in order to find faults and non conformance within the G-Tech model so to make improvements, record and archive information and so avoid the future replication of errors.

G-Tech Adoption/Adaptation

To make such a model work it is necessary to understand the industry, the organizational and project context, the technical and the social systems involved. The introduction of the model to the UK construction industry will give confidence to clients and their project team enhancing 'buy in' from stakeholders and organizations. Once satisfied with the potential of the model these stakeholders will adapt and adopt appropriate procurement and design frameworks and processes in order to meet the specific client as well as project needs. Innovative methods of information transfer will occur through partnering and use of the Clients brief as explained by Barrett et al (1999). Likewise knowledge transfer will occur both explicitly and tacitly described by Barrett and Gilkinson (2004). This is inclusive within the frameworks that will contain multi level with multi actor innovations.

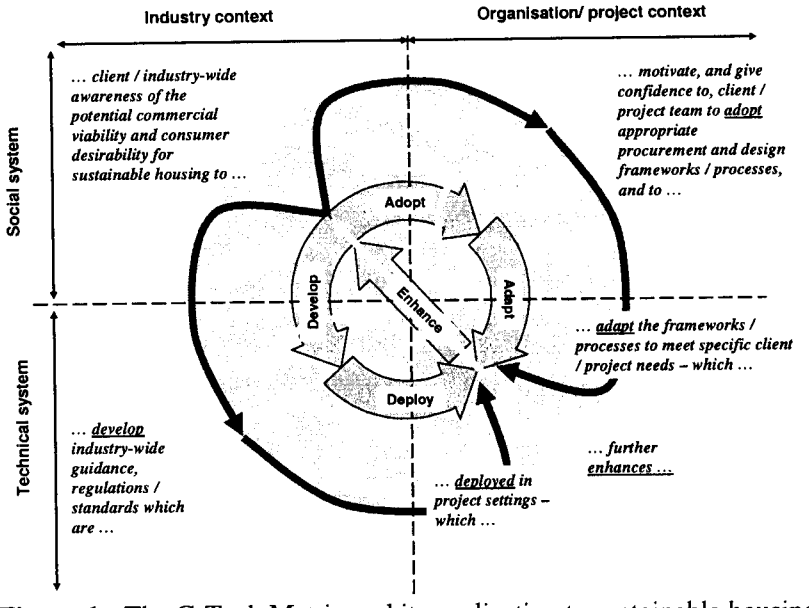

***Figure 1** : The G-Tech Matrix and its application to sustainable housing*

Here the G-Tech model illustrates how the mechanism develops for adoption through adaptation by industry through various deployment processes. Once **enhanced** this will motivate, and give confidence to, clients and project teams to **adopt** appropriate procurement and design frameworks and processes to **develop** industry wide guidance, regulations and standards which are **deployed** in project settings. The frameworks are then adapted to suite the processes to meet specific client/project needs (seamless delivery aspects) which in turn enhances industry awareness of green technologies. The outcome will be the construction and refurbishment of the effectively efficient socially acceptable, environmentally friendly and economically viable construction and use of modern housing. The model considers all those aspects relevant to the full integration of construction processes throughout. Fig. 2 shows how considerations for and allowance within the framework allows for product innovation, process innovation and process innovation.

Figure 2 shows how the product, process and supra innovation systems fit into the systemic model. Highlighted is the circular flow of innovation allowing for process and performance improvements. The model shows that what ever point in the construction life cycle the individual stakeholder works they can intercalate with their specific role affecting the various surrounding project participants. In addition the illustration shows how the model is not only systemic but considers all holistic service in use issues. Once disseminated the program of research will then respond to client/industry-wide awareness, thus the potential commercial viability and consumer desirability for sustainable housing. Pilots of the conceptual model will be executed

for validation taking into consideration that the circular flow allows for performance improvement. Such improvements will be made and from that the proper seamless delivery for sustainable housing will be achieved.

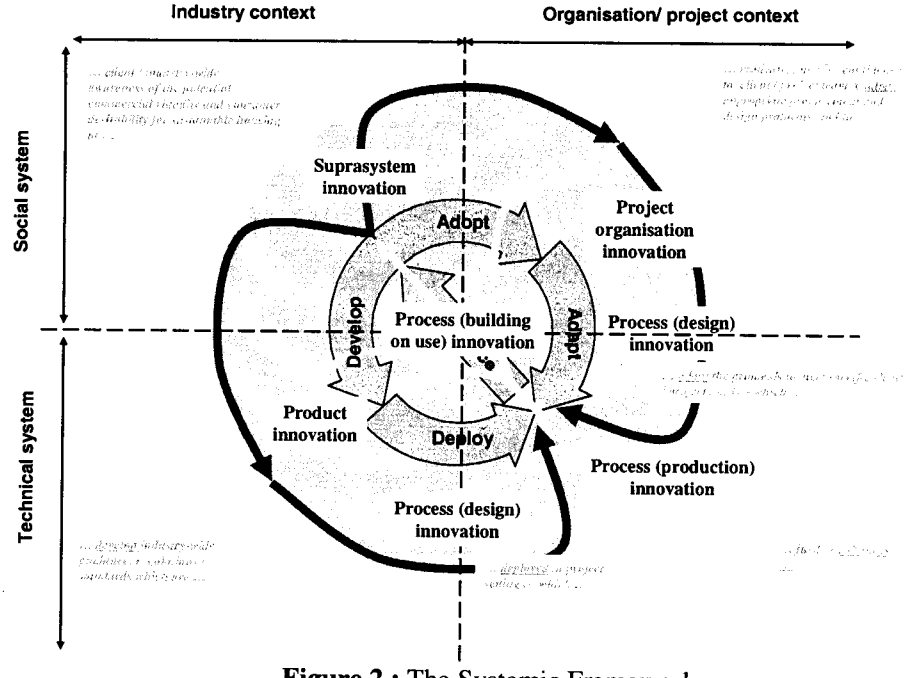

Figure 2 : The Systemic Framework

Conclusion

Government **policy** is changing with consideration for the social, economical and environmental pillars of sustainability focusing on individual regions and their needs; calling for frameworks to cater per se. Presently such government policy encourages house owners to consider their home as a product and an asset to use wisely (HM Treasury 2005). G-tech differs as its vision outlines the development, construction, maintenance and refurbishment of the home as a dual purpose service considering multi level factors that have a positive effect on the macroeconomics of the U.K industry. The model will review housing policy constraints and its supply & demand, focusing on the centralization of demand within regions. This will inspire and aid prompt a more generic method of assessing and measuring sustainable housing and their communities. The type of house selected for use per region will decide upon various issues such as the regions industry, age of community and stakeholder involvement. The perceived G-Tech framework will inspire policy to provide

subsidies and incentives for using renewable energy resources such as solar and innovative low energy technologies.

The **methodology** will include literature reviews, qualitative research through interviews, case studies and prototype validation with testing. Part of the study will provide weighting to sustainable practices consisting of comparative analysis as the model captures information to establish feasible improvements in the use of material resources and better more efficient processes. Regarding organizational and people issues the study will consider the barriers to the **adoption, implementation and application** of the G-Tech model with the intent to inspire interest naturally through peoples mindsets. Mechanisms and frameworks for procuring the construction would then occur as the full project supply chain including end users come together to provide a program engaging all stakeholders through transparency and trust encouraging value over cost.

Relevant to the **product service and operations** the study will analyze the separate product life cycles and material characteristics providing the best solution per construction type. Again influencing policy and product specification providing material production archives considering new build and the 'reconstruction redevelopment' of material resources following demolition. All stakeholders will have access to all such archives.

It is perceived that this study will affect the **social, political and research communities** both internationally and nationally. G-Tech will introduce a systemic, evolutionary innovation framework which stimulates the successful sustainable housing package. All information capture will take place at the micro level and from this incentivise those at the macro level. Further to this it is understood that the impact on policy inclusive of institutional, regional and national union will inspire industry leaders and suppliers to demand for sustainable house technologies and mechanisms. In addition **performance improvement** will be recognised as a quality standard achieved through social, economical and environmental assessments. All of this contributes to a sustainable community of which there is no generic strategy to date. It is perceived that as the model is deployed in UK project settings industry wide guidance and codes of practice will develop standards and regulation that enhance the sustainability agenda.

The study backed up by successful research council funding (EPSRC) and engagement with industry will provide a high caliber of research outputs. One of the **deliverables** is to achieve the development of a Sustainable Housing Research, Information and Consultancy Centre by 2011 using split funding from government bodies and industry participants. The centre will disseminate and promote deliverables from the project study to housing stakeholders, service providers and end users. This knowledge transfer may well lead to the tipping point required explained by Gladwell (2004) for the full adoption of the sustainable housing framework as

peoples mindsets change to suit the housing revolution process. This will then provide the systemic socially, environmentally and economically integrated seamless strategy for sustainable housing.

References

1. Barker, K (2004) Barker 33 Cross Industry Group: An Examination of the Barriers to the Greater Use of Modern Methods of Construction in the Provision of New Housing and the Mechanisms to overcome them. HM Treasury
2. Barker, K (2004) Review of Housing Supply: Delivering Stability: Securing our Future Housing Needs, HM Treasury, Crown Copy Right
3. Barker, K (2005) Review of Housing Supply, Sustainable Communities, Office of the Deputy Prime Minister. HM Treasury, Crown Copy Right
4. Barrett P. (2005) Revaluing Construction – A Global CIB Agenda, CIB Report 305. CIB Rotterdam.
5. Barrett and Gilkinson (2004) The Unanticipated Impacts of Research on Practive. CIB World Congress Canada 2004
6. Barrett, P.S., Sexton, M. and Stanley, C. (1999) Key Improvement Areas for Better Briefing Paper published in the proceedings of the Joint Triennial Symposium (CIB Commissions W55 & W65 with the participation of W92), Customer Satisfaction: A Focus for Research & Practice, Cape Town, South Africa, 5-10 September 1999, Volume 1, pp 535-545, ISBN 0-620-23944-1, CIB Publication Number 234.
7. Best, R. and Shucksmith, M. (2006) Homes for Rural Communties: report of the Joseph Rowntree Foundation Rural Housing Policy Forum. ISBN-13: 978 1 85935 493 3, ISBN-10: 1 85935 493 9
8. Boardman, B. Darby, S. Killip, G. Hinnells, M. Jardine, C.N. Palmer, J. and Sinden, G. (2005) 40% House, Environmental Change Institute, University of Oxford, ISBN 1874370397
9. Brundtland, G.H. (1987) Our Common Future Report of the World Commission on Environmental and Development, Oxford, Oxford University Press
10. Communities & Local Government Housing Statistics (2006) Warwick Business School Copyright, ISBN 139780117539723
11. Communities & Local Government (2006) Building a Greener Future: Towards Zero Carbon Development. Crown Copyright, Code 06SCDD04276
12. Curwell, S. Deakin, M. Symes, M. (2005) Sustainable urban development. Volume 1: the framework and protocols for environmental assessment. London: Routledge. 2005. 257 p.

13. Department for Communities and Local Government (2006) Designed for Manufacture – The Challenge to Build a Quality Home for £60k. Lessons Learned

14. DEFRA (2004) Energy efficiency: the Government's Plan for Action. UK Department for Environment, Food and Rural Affairs. Cm 6168, Stationery Office, London.

15. Department of Trade & Industry (2006) Construction Statistics Annual Report, London: TSO, ISBN 011515518X

16. Department of the Environment, Transport and Regions (DETR) (2000) UK Roundtable on Sustainable Development, fifth annual report

17. Fairclough, J. Sir (2002) Rethinking Construction Innovation and Research A Review of Government R & D Policies and Practices, Department of Trade and Industry (DETR)

18. Gilkinson, N.R. Curwell, S. and Cooper, R (2005) Contribution of the Construction Industry to the Exacerbation of Global Warming, SCRI Symposium U.K.

19. Gladwell (2004) The Tipping Point, Sage Publications

20. Henrich, G. and Koskela, L. (2006) History and Expectations of Production Management Methods in Construction, Construction in the XXI Century: local and global challenges - ARTEC - Rome, Italy. P. 144 - 145.

21. HM Treasury (2005) Housing Policy; An Overview, Office of the Deputy Prime Minister: Creating Sustainable Communities. Crown Copy Right, the Controller of Her Majesty's Stationery Office.

22. Housing Forum (2002) Homing in on Excellence. A Commentary on the use of offsite Fabrication Methods for the U.K. Housing Building Industry

23. Lee, A. Cooper, R. Prof. Aouad and, A. Prof. and Fleming, A (2000) The Development of a Process Mapping Methodology for The Process Protocol Level 2, Product and Process Modelling European Conference, Portugal

24. Lomas K, Oreszczyn T, Shipworth D, Wright A J and Summerfield A J (2006) Carbon Reduction in Buildings (CaRB) - Understanding the social and technical factors that influence energy use in UK buildings - paper to RICS Annual Conference Cobra, London, 7-8 September 2006.

25. Meadows, D.H., Randers, J. Meadows, D.L. (2004) Limits to Growth: The 30-Year Update, Publishing Company ISBN-10: 193149858X, ISBN-13: 978-1931498586

26. National Audit Office (2005) Using Modern Methods of Construction to build Homes more quickly and Efficiently

27. Peacock, A. Newborough, M. and Banfill, P. (2005) Technology assessment for radically improving the built asset base, World Renewable Energy Congress, Aberdeen, May 23-26

28. Rao, S. Yates, A. Brownhill, D. (2003) ECOHOMES:The environmental rating for homes. Building Research Establishment (Bre)

29. Sigmond, M. Siegmund, P.C. Kelder, H. (2003) The Effect of Tropospheric (Stratospheric) Co2 Increase on the Stratosphere (Troposphere) As Simulated With Ma-Echam 4. European Geophysical Society

30. Shipworth D (2006) Socio-Technical Input-Output Life-Cycle Assessment: Linking the social psychology of consumption to Input-Output Life-Cycle Assessment of production through graphical models - Journal of Cleaner Production special issue on: 'Sustainable Production and Consumption - Making the Connection'.

31. Tzortzopoulos, P. Chan, P. Cooper, R. (2005) Fuzzy front-end of design in the NHS MaST LIFT Primary Healthcare Projects Research Report